William Hen

ESSAYS,

PHILOSOPHICAL

AND

CHEMICAL.

BY A GENTLEMAN
OF EXETER.

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The Editor of theſe Eſſays is conſcious that ſome apology may be expected for the liberty he has taken in preſenting them to the Public in their preſent ſhape. His motives for having done ſo were, a deſire to bring them into general notice, and the ſolicitation of many gentlemen of the firſt eminence in the ſcience of which the Eſſays profeſs to treat.

The former of theſe motives was ſuggeſted by the conviction, that chemical and philoſophical enquirers might overlook the Eſſays in the ſituation in which they originally appeared. By the latter motive he ſhould not have been actuated, had the gentlemen alluded to been perſonal friends of the reputed Author * of at leaſt one of theſe Eſſays; for he is well aware, that the ſolicitations of partial admirers have been adverſe rather than propitious to the advancement of knowledge.

He has, with the aſſiſtance of thoſe who adviſed the publication, paid ſuch attention to the correction of the preſs, that it is preſumed the text is more accurate than from the hands of the Author.

It only remains for the Editor to ſay, that he truſts the Author of the Eſſays contained in the following pages will not conſider his conduct to be diſreſpectful; and that he knows the Volume of Eſſays publiſhed by the Society of Exeter, is too full of valuable information to ſuffer material injury from the preſent Publication.

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* One of theſe Eſſays, the 2d, is attributed, in a reſpectable periodical work, the Annals of Agriculture, to *Dr Parr of Exeter*.

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SOME CURSORY REMARKS

ON THE

Preſent State of Philoſophy and Science.

Flits o'er the deep, nor wets his wing.

THE hiſtory of Antient Philoſophy exhibits ſometimes a picture of a lively imagination, eſcaping from the fetters of obſervation; of an imagination eccentric, ingenious, and occaſionally deluded; ſometimes the ſublime ſpectacle of the human mind, burſting by its efforts through the ſurrounding darkneſs, glancing at Omnipotence, and tracing its finger through the myſterious mazes of human life. It more frequently diſplays only ſpeculative refinements on ſubjects, where certainty cannot be obtained, and a ſcholaſtic ſubtilty, where words hold the place of ideas, and empty ſounds are ſubſtituted for ſolid information. But of what is now called ſcience, the ſages of Greece had little knowledge. Pythagoras brought his ſyſtem from another region: it was taught, commented on, and forgotten. To Moſes much knowledge was attributed; but he ſeems to have been rather the inſtrument of the Supreme Agent, to whom the miraculous torments of Pharoah were owing, than a philoſopher peculiarly wiſe, or an obſerver ſingularly acute. The miracles of Moſes were too ſtriking not to have been remembered in the Pagan world; they have been preſerved either by hiſtory or tradition, and attributed to various fabulous perſonages of remote antiquity. That Moſes ſometimes availed himſelf of natural appearances, will be obvious; yet various circumſtances may be adduced to ſhow, that what appears moſt conſiſtent with the foreſight acquired by ſcience, muſt have been occaſioned by ſuperior influence, by divine inſpiration. Mr. Bruce has ſhown, that the eaſt wind was calculated to dry up the Red ſea, and has recorded the appearance of pillars of fire; but the eaſt wind has ſince prevailed, and the Red ſea has not been dried; and pillars of fire have appeared, but never, as the Moſaic hiſtory records, in the night. Serpents may become immoveable rods in the hands of the Pſylli; but the great ſerpent of the wilderneſs, which preys on the reſt of its race, has not yet been obedient to their powers. An electrician might inſulate an ark, and charge it ſo as to ſtrike thoſe who touched it; but he could not preſerve its virtue; and the beſt informed follower of Stahl would not find it eaſy, in the wilderneſs, to make an impalpable powder of the golden calf. As we cannot draw the line between the works of the Almighty, and the foreſight of the legiſlator, "ſkilled in all the knowledge of the Ægyptians," we are unable to aſcertain the ſcientific acquiſitions of the Iſraelites. We find few traces of ſcience in the ſubſequent ages down to the periods of Solomon and Daniel. If we except what is ſaid of Solomon's acquaintance with the vegetable ſyſtem, and what we know of his political diſcernment, the works of the former diſplay only the excellent and practical maxims of the moraliſt; and in the latter we perceive a fervid unaffected piety, joined with the political acquiſitions of a ſtateſman. Yet to Solomon has been attributed all that Greece afterwards knew of arts and ſciences, all that the Alchemiſts boaſt of their tranſmuting power; and to Daniel the whole circle of Ariſtotelian philoſophy.

What the philoſophers of Greece knew, they knew but imperfectly, if we except only Ariſtotle. His comprehenſive mind ſurveyed every thing in its varied lights, and ſaw the different combinations of which each ſubject admitted. In the ſcience of natural hiſtory his knowledge was extenſive; and in phyſics, particularly in what relates to the air, he knew, without the aſſiſtance of the air-pump, what that inſtrument has been ſuppoſed to have diſcovered.

ed. He knew that air was heavy, and that, from the light, the colour of plants was derived.

It is ſurpriſing that the philoſophy of Ariſtotle did not receive, in the middle ages, the attention which was paid to his dialectics. *Theſe* monopolized the care of the philoſophers, to whom Ariſtotle, after a long period of ignorance, was firſt known, and ſcience ſoon became a conteſt of words. It ſunk, to riſe with ſplendour, in all its varied branches; and if, as ſome have propheſied, it has paſſed its zenith, and we now admire the mild radience of its weſtern rays, without expecting it again to dazzle with meridian ſplendour, it muſt be at leaſt allowed, that its fall is reſpectable. Frivolous purſuits, indeed, employ the attention of ſome philoſophers: indolence has ſeized others, from whom much was expected; while a whole nation, deſolated by faction, appears to behold, with equal indifference, the ruin of ſcience, of elegance, and taſte. But we need not deſpair: we ſhall have occaſion to ſhow, that torpor has not ſeized every individual;

dual; anarchy has not diſtracted every nation; while the diſcovery of new regions, and a more intimate acquaintance with extenſive countries, before imperfectly known, have enlarged the limits of ſcience, and opened the proſpect of new and unexpected acquiſitions.

To riſe above the topics of the day, the idle converſation of the frivolous and indolent, was the object of our inſtitution. It gives me pleaſure to be able to congratulate you on our ſucceſs; and we may indulge the ſatisfaction of reflecting that our union will be equally permanent, inſtructive, and entertaining.—From the colliſion of varied ſentiments, the moſt able may receive information; from the compariſon of ideas formed under circumſtances very different, and with views diſſimilar, truth will be often ſucceſsfully elicited. In the philological inveſtigations, the mind will be elegantly entertained, its powers augmented by the exerciſe of critical diſcernment, and the judgment ſtrengthened by inveſtigating the ſources of error.

Tho' ſecluded in the corner of an iſland, ſuch is the force of expanding truth, ſo penetrating its rays, and ſo generally diſfuſed its cheering light, that local ſituation cannot materially injure us. At this æra, the mind ſeems eager to expatiate beyond the former confines: the extravagant, and ſometimes the erring, ſpirit, contribute equally to the diffuſion of knowledge by new diſcoveries, or by the ruinous reſult of ſpecious and deluding projects. The philoſophers of France long ago raiſed an imaginary fabric of fancied excellence. The bubble was blown, and expanded to a promiſing ſize; but it burſt, and threatens to involve in its deſtruction, a flouriſhing kingdom, arts, ſciences, agriculture, and commerce. It is an inſtance of the mind ſpeculating, without the regulating balance of judgment; eagerly graſping at an apparent good, without weighing the danger which muſt reſult from the inſtruments employed; purſuing with a dangerous violence, what might be ſafely obtained by a more calm, a more matured, and a ſlower progreſs. But it is an inſtance alſo, that the human mind be-

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gins to riſe above the trammels of cuſtom; that the active ſpirit has eſcaped from the ſhackles of prejudice; that, feeling innate powers, it eagerly preſſes forward to exertion.

In other ſciences, the progreſſive exertions of human reaſon afford a more pleaſing picture. Tho' ſome wanderings have occaſionally miſled philoſophers; though hypotheſis, fancy, and ſpeculation have, in a few inſtances, deluded them, they have in general preſſed with firm and ſteady ſteps towards the temple of truth. A very few years have elapſed, ſince the ultimate analyſes of natural bodies were but at a little diſtance from their common forms. At preſent, more is known of the nature of each claſs of bodies, than had been diſcovered of all. Air was found to eſcape in the various proceſſes of decompoſition. From this leading fact, Dr. Hales firſt ſtruck the ſpark of future diſcoveries; Dr. Black cheriſhed and animated it; Dr. Prieſtley raiſed it into a flame; Kirwan, Cavendiſh, Lavoiſier, Berthollet, and Fourcroy, have, from this ſource, kindled torches, which have illuminated nature in her moſt remote receſſes. In this progreſs, ſciences and arts have been materially aſſiſted. Our dyes have aſſumed a ſuperior luſtre, our linen a more immaculate whiteneſs; our glaſs vies more ſucceſsfully with the cryſtal; iron aſſumes, in the mould, forms more delicate than the hammer can beſtow; ſtuccos become little inferior to the marble which they emulate, and our porcelain equals in ſubſtance, and in form excels the rival manufactures of China.

In philoſophy, our acquiſitions have taught us to guard againſt the thunderbolt, to counteract, by the ſuperior power of ſteam, the moſt copious fountains of ſubterraneous water, to bring the heavenly bodies more completely within our view; and, when we ſee that the apparently uncompounded element, water, may become air, and again, by a proceſs certainly ſimple, tho' not fully underſtood, regain its more material form, we begin to diſcover the real cauſes of thoſe common changes in the atmoſphere, which philoſophers have hitherto imperfectly comprehended.

An obſcure ſubject has lately been illuminated by a ſlight ray, which leads to vaſt and extenſive proſpects. But the whole is yet little more than ſpeculation, tho' in ſuch a queſtionable ſhape, that it may be allowable to notice what has hitherto been done. The torpedo and the electrical eel from Surinam, are known to produce ſhocks of the electrical kind, and it is equally well known, that the organs which produce the effect, have a very large and an unuſual proportion of nerves. By an accident, Cotunnio of Bologna found a ſimilar effect in diſſecting a living mouſe. Galvani has purſued the ſubject; Valli, Fowler, and Monro followed it farther. Little more has, however, been diſcovered, than that the nervous fluid ſeems to be electrical, that muſcular exertions depend on the ſudden and violent influx of this fluid, which various medicines and applications will render leſs mobile, and which may be conveyed by metallic conductors.—Much, indeed, is required in addition and explanation of what is known; but when we reflect that the coheſion of animal fibres depends on the principle of life, and that digeſtion is deſtroyed by intercepting the nervous influence of the ſtomach; that heat depends on the living principle, and putrefaction ſoon comes on, if the nervous influence be interrupted; it will at once appear that this firſt ſtep may conſiderably elucidate the nature of the animal œconomy, and greatly influence every department of philoſophy. If, however, by the proceſs, the natural electricity of bodies is augmented, and this increaſed power only operates on the nerves, in the manner formerly obſerved, tho' not explained, all theſe brilliant proſpects will be obſcured, all this deluſive colouring darkened, and the nature of the nervous power ſtill continue among the deſiderata of phyſiology.

Fire, the great agent of the chemiſt, for a while eluded the analyſis of the moſt penetrating philoſophers, nor could we have heard without the greateſt aſtoniſhment, that it could be transferred from one body to another, with as much eaſe as any other ingredient. It is now diſcovered to be a principle, more ſubtile, probably, than any other, and perhaps never ſeen wholly ſeparate; for in the pureſt flame it is combined with light, with the exhalations of the burning body, and with water. The moſt aſtoniſhing exertions of the mind, in an æra, diſtinguiſhed by ſurpriſing diſcoveries, joined with ſingular ingenuity, have detected fire in an aerial form, without its ſenſible qualities, and in a ſtate, probably, the leaſt compounded. It is found, where it would be leaſt expected, in the pureſt, and, as it has been ſtyled, without any reference to theory, *empyreal* air. Vital air contains 87 times more heat, in a given bulk, than the pureſt ſpirit of wine, and 870 times more than the fineſt oil*. I may juſt add, among the diſcoveries which have occurred within a few years, the means of meaſuring heat. Mr. Wedgwood's thermometer of contracting clay, has each degree equal to 130° of Farenheit; in other words, the greateſt difference we experience from the ſevereſt winter to the moſt fervent ſummer, amounts but to half a degree of this comprehenſive inſtrument; and it is capable of meaſuring heat equal to what would raiſe Farenheit's thermometer, if the ſubſtances would admit of the experiment, 32,277°.

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* Bergman and Lavoiſier's tables.

The other kinds of air, one only excepted, appear to be well known ſubſtances in a new form; and it is among the lateſt diſcoveries, completed at leaſt by the Engliſh chemiſts, that fixed air is only charcoal in this expanded ſtate. Charcoal affords this air, and in affording it almoſt diſappears; the air may be again brought to aſſume the appearances and properties of charcoal, unchanged and undiminiſhed. The only exception above alluded to, is the inflammable air, of which we know little, except that it is, in general, the antagonizing principle of vital air. In ſolid bodies, they uſually expel each other: in fluid ones they exiſt together, for the reſult of their union is now very generally agreed to be water.

This doctrine has begun to influence the explanation of different phænomena of the animal œconomy. In the compoſition of the fluids, the various gaſſes muſt have conſiderable influence; and, in diſeaſes, much will depend on the proportion of ſome, and the abſence of others. If not forbidden by our rules to be profeſſional, I could *not* enlarge much on this head, for the application of the doctrine is yet by no means clear. Dr. Beddoes has lately contributed to retard the progreſs of this kind of inveſtigation, by carrying it farther than obſervation will ſupport him. But we may add, that, in explaining the nature of cancers, ſea ſcurvy, phthiſis pulmonalis, and ſome cutaneous complaints, the doctrines of air will be chiefly uſeful; in theſe too. if applicable as remedies, the different gaſſes will be found moſt ſalutary.

Thus extended are the limits of natural knowledge, and the conſequences we have already noticed. They are numerous, ſplendid, and important; the advantages derived by the manufacturer and artiſt, are equally valuable. Theſe it is impoſſible wholly to explain: the practical application of many of the late diſcoveries is purchaſed by the manufacturers, ſecured by patent, and explained only by a deluſive, but plauſible ſpecification.

In geography, within nearly the ſame period, the diſcoveries have been almoſt as numerous. The energy of mind, which led Columbus to explore the oppoſite ſhores of the Atlantic, has, at this period, led the philoſopher to the iſlands of the Pacific, to deſtroy the viſionary phantom of a ſouthern continent; and to aſcertain the vicinity of the two known continents on the north-eaſtern ſide of Europe. Science has greatly profited by theſe attempts: humanity and benevolence may rejoice that their cauſe has been equally aſſiſted. The diſeaſes, ſuppoſed to be eſſentially connected with navigation, have been averted by the exertions of common prudence, and plain but penetrating good ſenſe; nor can the annals of the world equal the late deſign of tranſporting a vegetable, eſſentially uſeful to life, in a ſtove, conſtructed in a ſhip, over ten thouſand miles of ocean, through climates dangerous from ſtorms, and eſſentially varying in degrees of heat.

The voyages of our countrymen, at this

æra, have greatly added to the ſtock of natural hiſtory. Numerous new vegetables, many of them highly uſeful, have been diſcovered; and the 20,000 ſpecies which Linnæus once ſaid, by a pretty certain calculation,—"calculo ſatis certo," would probably limit our vegetable riches, have been already nearly doubled. Our territorial acquiſitions in India have greatly augmented the ſcience of botany. The various new plants from this country have enriched our conſervatories, and added to our botanical knowledge. We may be allowed to hope, that the plan of forming a complete ſyſtematic treatiſe of the plants of India, ſuggeſted by Sir William Jones, will not be forgotten. Many elucidations of the antient authors, who ſpeak of the plants of India, will probably occur, of which we have one ſpecimen in the Aſiatic Reſearches. The ſpikenard of the antients appears to be a ſpecies of valerian; for a plant, reſembling, in all its properties, what Arrian and others have recorded of the ſpikenard, is found to belong to this well-known genus, and probably it is not very diſtant from the other ſpecies of valerian, in its medical properties.

The vegetable riches of New South Wales appear not, at preſent, very intereſting. Time may inform us of the qualities of the vegetable ſubſtances already diſcovered, or add to the catalogue; but, at preſent, we know not that the peppermint tree is preferable to the European ſhrub, the red rezin to the kino of Africa, or the yellow, to the balſam of Tolu.

In the animal kingdom, we now are acquainted with the pangolin, a ſingular creature, which, like the mole, reſides in the earth, and which, from the cartilaginous and muſcular ſtructure of its ſtomach, unites the quadrupeds with the birds. No animal or vegetable ſubſtance has been found in its ſtomach, and it has been ſuppoſed, that it may be nouriſhed by mineral ſubſtances. The obſervation does not, however, ſupport the concluſion; for, like the ſalmon, in whoſe ſtomach nothing is uſually diſcovered, the digeſtion may be peculiarly rapid: or, like other animals living without light or air, it may be able to bear a long interval between the hours of feeding. An animal, who ſeems not to poſſeſs the faculty of viſion in a degree peculiarly acute, or a ſenſe of ſmell ſo nice, as to diſtinguiſh accurately its proper food, would probably require a ſtomach which could receive no injury from ſubſtances unſuitable to its conſtitution. If the pangolin fed on worms, with them it might take in the calcareous, and probably the flinty particles of the ſoil where it lives, which in a ſtomach ſo carefully conſtructed, can do no injury. This final cauſe is ſupported by what has been obſerved of the gallinaceous tribe, for Spalanzani has rendered it uncertain, whether they ſwallow the fragments of gravel by accident or from inſtinct, for the purpoſe of triturating their food; and from the diſſection of ſtone-eaters, the coats of whoſe ſtomachs have been found indurated and cartilaginous.

It was not eaſy, in this ſketch of the preſent ſtate of ſcience, to paſs over an animal ſo ſingular as the pangolin, without a more particular attention than can be beſtowed on individuals, whoſe connection with the more general doctrines of natural hiſtory is leſs ſtriking. Though, therefore, our acquiſitions in the order of birds and of inſects are numerous, it is impoſſible to mention them diſtinctly. Among the birds, where we find few ſpecies peculiarly docile and intelligent, one may deſerve notice. The Indian groſs-beak builds its neſt with a care and an extent of judgment ſeemingly ſuperior to inſtinct, ſcarcely ſhort, indeed, of reaſon. It is ſuſpended over water, to be ſecure from ſerpents; its entrance is narrow, and from below, to avoid the depredations of birds of prey. Many ſuppoſe that it illuminates its neſt with fire-flies, which it fixes on the ſides with cow-dung: it is, at leaſt, allowed that fire-flies are found in this ſituation, tho' uncertain whether deſigned for food or for convenience. Theſe marks of judgment and foreſight are not, probably, accidental, for the bird is peculiarly docile and obedient; and, when we add, that the groſs-beak is of the ſparrow kind, theſe marks of intellect will appear more ſingular.

Minerals have alſo been diſcovered within theſe few years, poſſeſſing new and uſeful properties. Scotland has been found to produce a new earth ; New South Wales a clay ſeemingly different from the other ſpecies of the argillaceous kind. From the jargon of Ceylon an earth of a particular kind, not hitherto known, has been ſeparated ; and from the Eaſt Indies we have procured a ſpar equalling in hardneſs the diamond, and called, in conſequence of this property, adamantine.

While Scotland has afforded the new earth to which the name of Stronthian has, from the place where it was diſcovered, been given by Mr. Kirwan, our neighbouring county has afforded a new metal. The menackanite of Cornwall appears to poſſeſs very peculiar properties, which have not yet been found united in any one ſubſtance of the metallic kind ; and tho' its appearance, and in ſome meaſure its properties, ſeem to reſemble thoſe of iron, yet they differ ſo much from iron, as may probably render it uſeful in many arts. The effects of the acid of phoſphorus in diſguiſing many bodies, and rendering them capable of reſiſting the moſt powerful agents, muſt always be kept in view by the cautious mineralogiſt. In its combination with iron, it for a time eluded the moſt accurate analyſes, and the beſt chemiſts ſuppoſed they had diſcovered a new metal, which, from its connection with iron, they called Siderite. Before, therefore, the Corniſh metal can be ſtyled new, it muſt be again examined with a ſuſpicious caution. But, tho not new, it may be uſeful and important; tho' a combination, it may be extenſively applicable. The barytes, for inſtance, an earth diſcovered ſome years ſince, in many reſpects reſembles lime, yet it affords a ſalutary medicine, poſſeſſes powers found in no combination of calcareous earth, and is a re-agent of peculiar utility, becauſe in its union with vitriolic acid, it is almoſt inſoluble. If the aerated barytes deſcribed by Dr. Withering, be ever met with in extenſive ſtrata, it may be ſingularly uſeful, as affording an eaſy method of preſerving water from putrefaction in long voyages*. The ſtronthian earth alſo, if it ſhould appear to be a new form only of a ſubſtance formerly known, may, from its eaſy fuſibility in particular circumſtances, afford a valuable reſource for enamellers. The manganeſe, which abounds in peculiar perfection in this county, was long ſuppoſed to be a magnetic ore of iron; but even conſidered in this light, the glaſs-manufacturer found it more uſeful than any other ferrugineous ſubſtance; and its valuable qualities have ſince been extended to the potteries and the bleachfield, in which it is now an indiſpenſable material.

I have engaged in this ſhort digreſſion, to oppoſe objections often repeated; to obviate cavilling often heard from thoſe who do not diſtinguiſh between the name and the properties, who leſſen the value of a diſcovery, becauſe its baſis appears from inveſtigation to have been before known. Many ſimilar facts might have been added, which would have rendered this part of the ſketch both tedious and diſproportioned.

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* A ſmall proportion of vitriolic acid, added to water, will prevent it from putrifying: and this acid may be completely precipitated by the aerated barytes, which is inſoluble, when united with the acid.

When I formerly mentioned the improvements in the porcelain, it was not the place to add the cauſes of its excellence. The materials which occaſion its peculiar value are chiefly found in this and the neighbouring county. Indeed Devonſhire wants only to be examined by an able mineralogiſt. Its clays are excellent; its manganeſe of a very ſuperior quality; and its marbles, in their beauty and variety, emulate thoſe of Italy.

Europe has ſeen, with aſtoniſhment, the enterprizes of the Engliſh in the Eaſt. They have ſeen a body of merchants, extending their power over the territory of Aurengzebe, exerciſing ſupreme dominion over countries more extenſive than

Europe, forming an imperium in imperio unknown to hiſtory, which the politician views with aſtoniſhment and dread, the philoſopher with an anxious impatient curioſity. It is not my buſineſs to eſtimate the effects of the wealth of Hindoſtan tranſported to this country, the diſproportioned magnitude of the appendage of a ſmall but powerful nation, or the conſequence which the influence of the eaſt may have on the political ſyſtem of the weſt. To literature, our extended empire in the eaſt has greatly contributed; and whatever opinion be formed of Mr. Haſtings as a politician or governor, he muſt be conſidered as the greateſt benefactor learning ever had. It is not eaſy to believe that the man to whom the mild, blameleſs Bramin opened the ſacred vedas, to whoſe influence it is owing that we have traced philoſophy to her cradle, and examined her, while advancing, with unequal ſteps, to a vigorous manhood, could have been a cruel tyrant.

The Arabians, in the middle ages, kept alive the ſparks of learning; and it was for this reaſon that their language became an eſſential part of a learned education. Thus feebly cheriſhed, and almoſt neglected, it was ſoon cultivated with another view; and the language of Arabia, the parent of the Perſian, and of the Hindû, was an object of attention to every eaſtern adventurer. To this neceſſary acquiſition was ſoon added another more uſeful to the philoſophical enquirer, viz. the Sanſcrit, the religious language of Hindoſtan, the ſacred repoſitory of their myſteries, their religion, and their philoſophy.—With theſe keys the holy cabinet has been unlocked, and we have glanced at the ſacred treaſures, with an eager deſire to examine them more fully, to poſſeſs them more completely. I wiſh only at preſent to point out the very great and extenſive influence of what we have diſcovered in this repoſitory, on what we formerly knew. It is amongſt the moſt brilliant diſcoveries of this æra.

The hiſtories of the Grecian philoſophy in our language, have rather been the lives of men, than a connected ſyſtem of opinions.

nions. If the latter had been the object of the different hiſtorians, Pythagoras would have been the firſt object. His ſyſtem, whatever it really was, ſeems to have been the foundation of Socrates's ethics, of Plato's ſplendid fancies, of the more ſober ſyſtem of the Porch, and the more accommodating, more ſpecious, doctrines of Ariſtippus. Pythagoras, it is ſaid, travelled to Ægypt, and there attained his mathematical and aſtronomical knowledge, his religious and his metaphyſical ſyſtems.—The idea is abſurd, for his ſyſtem is not Ægyptian. He taught that the ſoul was rational, immaterial, and immortal. Of theſe tenets the Ægyptians had no idea. He inculcated the pure principles of liberty: the Ægyptians were at that time the ſervile inſtruments of a deſpot. He told his diſciples that there was one God—one, indiviſible, and immutable, while the Ægyptians devoured the leeks and onions, which they had adored. The tranſmigration of ſouls, and the conſequent doctrine of avoiding animal food, was equally unknown to thoſe who drank of the Nile. If then theſe tenets are inconſiſtent with the ſyſtem of the Ægyptians, and conſonant to thoſe of the Bramins, we can have little doubt of the ſource of the Grecian philoſophy. Their mythology has been already ſhown to be nearly connected with the fables of the Hindoos, by Sir William Jones, and the connection between Ægypt and India fully proved by Lieutenant Wilford.

The life of Pythagoras, as it has reached us, is only calculated to amuſe and aſtoniſh. That he went to Ægypt is certain; and, in Æthiopia, might have met with the Gymnoſophiſts, the naked philoſophers of the Nile, the degenerated diſciples of Bramha. He ſeems, however, to have gone farther; for Diogenes Laertius ſpeaks of his travelling among the Chaldæans, and the Magi; Cicero mentions his acquaintance with the Magi of Perſia, and Pliny his travels into Perſia, Arabia, and Æthiopia. Dr. Prideaux has endeavoured, with ſome ſucceſs, to prove that he was a ſcholar of Zoroaſter; I mean the ſecond of the name, who drew his doctrines, if we can judge from the ſtriking reſemblance between the Zend-aveſta and the ſyſtem of the followers of Bramha, from the Bramins.

Among theſe reſemblances, nothing is more ſtriking than the triple mithra of Perſia, and the divine triad of Bramha, Veeſhna, and Seeva; from either of which the Ægyptian trinity of the Globe, the Wing, and the Serpent, may have been formed, and the various alluſions of this kind in Plato and his followers derived. There is no more ſtriking diſſimilitude, than between this Trinity, the ſacred Oom of the Bramins or the holy Om of the Ægyptians, and the Quaternion of Pythagoras. Yet he probably accommodated himſelf to the languages more uſually known; and, as the ſacred name of the deity in the languages generally underſtood, were words of four letters, he might have thought his Quaternion would be better underſtood, than when compriſed in a word fabricated from the initials of the three principal attributes of Bramha.

From the late diſcoveries, and thoſe

points at preſent the ſubjects of inveſtigation, we ſhall probably find, that the mythology and the philoſophy of Greece is Indian; that the myſteries of the groves of Perſia and Hindoſtan were carried by the northern Scythians, bordering on India, to Scandinavia and Britain, where, with unimpaired veneration, the Druids and their bloody rites were conveyed; that the great antiquity of the Hindoos is in its more extraordinary outlines miſrepreſented, for the Yougs were probably the Magni Anni of the Sybils, the periods terminated by planetary revolutions, and the laſt only the real hiſtory of mankind; that the wars of the Giants or the Titans, taken from the battles of the Indian Soors and Aſoors, good and evil genii, are only the conteſts of the ſons of Shem and Ham for the empire of the infant world; and that the early divinities of Greece are to be looked for in the earth, in the ſun, and the air; in fire, and in water. Whether Chaldæa or India was firſt peopled; whether the Hebrew or the Sanſcrit was the original language; whether Hindoſtan and its records eſcaped the Moſaic deluge, is uncertain. Yet perhaps it will appear that to Chaldæa India was indebted for its firſt inhabitants, who, in return, peopled the eaſt; and if the Hebrew be the moſt ancient, the Sanſcrit, probably the parent of the Greek, has been more extenſively diffuſed. In ſhort, in this enlightened æra, every thing might have been expected, had not the fatal ſcourge of war been brandiſhed, and devaſtation taken place of peace and order, of cultivation and happineſs. May her triumph be of ſhort duration; and, diſtant from ſcenes of turbulence and confuſion, may we be ſenſible of that peculiarly happy ſituation, which enables us, uninterrupted, and in full ſecurity, to enjoy our literary amuſements, to catch, at leaſt, occaſional ſparks from the irradiations of ſcience, from the ſplendors which we admire at a diſtance.

S. I. S.

Aug. 22*d.* 1793.

REFLECTIONS

ON THE

COMPOSITION and DECOMPOSITION of the ATMOSPHERE,

As influencing METEOROLOGICAL PHÆNOMENA.

> Non uſitata nec tenui ferar
> Pennâ —— per liquidum Æthera.
>
> HORAT.

IF Syſtems have been ſometimes raſhly and haſtily conſtructed, without a due attention to the phænomena, and their reſpective relations, we have equal reaſon, at other periods, to lament that facts have been accumulated, without adverting to the conſequences, which may be drawn from them, when collected with care and compared with attention. From the unſuſpected coincidence of various obſervations,

tions, ſcattered in works not generally known, I mean, in the preſent eſſay, to draw concluſions, which may perhaps elucidate ſome important parts of Natural Philoſophy. At leaſt I ſhall bring together what is now widely diſperſed; and, though the reſults may appear, in ſome inſtances, incorrect, the facts themſelves are curious, and, in other hands, may lead to important conſequences.

RAIN is one of thoſe phænomena which has engaged, hitherto unſucceſsfully, the attention of philoſophers. The attempts to explain its cauſe were unſucceſsful, becauſe water and air were conſidered as unchangeable elements; and the philoſophical enquirers of the laſt century, if we except only Niewentyt, found the taſk of deſtroying former ſyſtems, and conſtructing others equally viſionary, not very difficult.

Dr. Franklin, Dr. Hamilton, Lord Kames, and M. Le Roy, about the ſame period, the middle of the preſent century, ſuggeſted a new ſyſtem, and contended for the priority, with a zeal uſually inſpired by the undiſputed diſcovery of an important truth. This doctrine of the ſolution of water in air, and ſubſequent depoſition in rain, was firſt hinted at by a late reſpectable philoſopher, Dr. Halley: yet, in this period of ſcience, when the doctrine was again revived, it lay ſo near the ſurface, that a ſlight penetration might have diſcovered it, and each author may have deſerved all the merit which the diſcovery ever could beſtow; but I leave the arguments and explanations in the different modern ſyſtems to be examined at leiſure. The whole is recommended by its ſimplicity, its perſpicuity, and the eaſe with which it ſeems applicable to the moſt important phænomena.

It was ſoon however found, that evaporation would go on in an exhauſted receiver; that, during the proceſs, heat diſappeared, and was again ſenſible when the water recovered its firſt form; and evaporation ſeemed alſo to take place from ice, when the air was below the freezing point. As heat is now known to be a peculiar ſubſtance, and not a modification of matter only, when it is loſt in the evaporation, it muſt become either an intermede, aſſiſting the ſolution, or an ingredient in the new compoſition. Something muſt therefore be added to the ſyſtem, the ſimplicity of which was ſo ſpecious, and appearance ſo ſeductive. The phænomena of dew ſeem to admit of the moſt eaſy explanation on this ſyſtem; but if this very frequent appearance requires an additional and a very different agent, it will be obvious, that the ſolution of water in air, though indiſputable as a fact, is limited in its operation and powers.

Thus far went M. de Luc, a laborious and ingenious philoſopher, hinting indeed at more, often without explaining what his additional views were; and this is the lateſt author who has aimed at novelty; for Dr. Hutton has only attempted to elucidate and enlarge the theory originally derived from Halley.

The foundation of all the errors, the ſource of all the difficulties on this ſubject, conſiſts in the common prejudice, that air and water are unchangeable elements. We *now* know that water may be formed from the union of two kinds of air, and may again be ſeparated into its conſtituent parts: In fact, that water and air are convertible, in various natural proceſſes, into each other. Why then may not theſe proceſſes go on alſo in the atmoſphere? Why may not the atmoſphere differ at times in its real abſolute quantity, as well as in its denſity and elaſticity? Why may not rain and dew be air converted into water? Theſe are queſtions which may be ſtarted as ſubjects of inveſtigation and enquiry; to ſharpen the mental powers by the diſcovery of new relations, which may give a certainty to what at firſt ſtarts forward in a queſtionable ſhape, or deſtroy a phantom, whoſe appearance is ſpecious but deluſive. I ſhall attempt to ſhow that theſe are not ſuppoſitions only; that meteorological phænomena really ſupport this variation of the quantity and ſtate of the atmoſphere, this change of water into air, and the contrary; that, in all theſe changes, there are concomitant appearances, which point out ſome of the agents by which they are probably produced.

The variation of the actual weight of the atmoſphere may be ſuppoſed ſufficiently clear from the different heights of the mercurial column in the barometer. I cannot however take this as ſatisfactory evidence, for, in general, the barometer is an inſtrument of a very complicated kind. Its height is not only a mark of the weight of the atmoſphere, but of its elaſticity alſo, which, in meaſuring the heights of mountains, is corrected, partly by the temperature. If, however, we look at the more extraordinary commotions in the atmoſphere, we ſhall ſee deciſive evidence of the variation of the quantity of air. In the deſcription of hurricanes, the wind is always ſaid to ruſh from every quarter at the ſame moment, and the barometer to have been peculiarly low ſome time preceding. It requires no argument to ſhow, that this cannot be the caſe, unleſs there is a comparative vacuum on the ſpot; and we ſhall ſee great reaſon to ſuppoſe, that the quantity of air may at any time be ſuddenly diminiſhed. The whirlwind and the waterſpout are appearances of the ſame kind, and differ only from the hurricane by the vacuum taking place in a ſpot ſtill more confined. The examination of theſe meteors firſt led me to the explanations I ſhall ſuggeſt. No reaſon could be given for the appearances of the waterſpout, if a vacuum did not exiſt. Suppoſing a vacuum to have taken place in that part of the air only, the water would be impelled upwards by the weight of the neighbouring air, and it would be impelled exactly in the manner uſually deſcribed, from the reſiſtance of the atmoſphere around. Thus water paſſing through the neck of a funnel, is ſeen to aſſume this ſpiral motion ; a bullet driven from a gun moves, in the ſame manner, through the whole of the barrel ; and it is mathematically demonſtrable, that it muſt aſſume this kind of motion from the compoſition and reſolution of forces. Winds are ſeemingly owing to a local vacuum in a leſs degree.—High winds are preceded by a falling of the barometer, while the elaſticity of the air remains the ſame. If they conſiſted only in the reſtoration of the equilibrium of the air, rarefied by heat, every wind ſhould feel ſharply cold; for, added to the coldneſs of the atmoſphere, which gave it denſity enough to ſupply the place of heated air, the percuſſion would render it more peculiarly piercing. The coldneſs we feel is from the force with which the heated atmoſphere is driven from the ſurface of our bodies; for wind often makes no change in the ſtate of the thermometer, when we feel it unpleaſantly ſharp.

Though facts oblige me to diſclaim the ſinking of the mercurial column as a mark of the diminiſhed weight of the atmoſphere, without ſome reſtrictions, it is undoubtedly in many caſes a proof of the diminution. If air aſſume the form of water, without any other change, we may preſume the whole ſhould continue equally heavy, or become more ſo; but we know that the water remains ſuſpended. On the contrary, when the ſtate of the air changes, the vapour in the clouds ought not to be heavier in the form of air, than it was in that of water. In both inſtances, the diminiſhed and increaſed elaſticity of the air have ſome effect; but, in the latter, there ſeems to be really an increaſe in the height of the atmoſphere. Evaporation begins immediately to take place on the ceſſation of rain; and, when comparative obſervations on hills, and in the vallies beneath, have been made, the rain in the vallies has always been found heavieſt at the beginning of a ſhower, and lighteſt at its end.

In determining this queſtion, the evidence of our feelings is equally equivocal; yet, like the changes in the barometer, they may come in aid of other arguments. The oppreſſion we often feel when the barometer is low, may be connected with the ſtate of vapour in the air, the want of its uſual elaſticity, ſince in ſuch circumſtances the air is remarkably inelaſtic, or to other cauſes. But, when we find that this extreme languor is felt on high mountains, where the preſſure of the air is greatly diminiſhed, we ſhall be inclined to attribute it in part to this cauſe. Some philoſophers have lately contended, that no languor is felt on the ſummits of the higheſt mountains;

tains; but Sauſſure found this oppreſſion very conſiderable on Mount Blanc, 2450 toiſes, little leſs than three miles, above the level of the ſea; indeed ſo great, that ſome of the guides, uſed to elevated ſpots, could not ſupport the ſudden and violent change.

The obſervations ſelected, ſhow that the quantity of air over given ſpots is probably at different times very different, from cauſes not yet explained. It is therefore neceſſary to adduce the evidence that renders the mutual converſion of water and air, in atmoſpherical phænomena highly probable.

If the doctrine of the ſolubility of water in air, and its ſubſequent decompoſition, were univerſally applicable to the theory of evaporation and rain, the diminution of heat muſt, in every circumſtance, be attended with the depoſition of water; and on the contrary, the depoſition ſhould be always connected with cold. In a certain degree, the former is true; but the latter ſcarcely obſervable in any inſtance. Indeed the oppoſite change is ſo conſiderable,

able, that rain muſt always, if this ſyſtem be adopted, counteract its own cauſe; for while evaporation is attended with cold, and the depoſition ſuffers the heat to eſcape, the temperature, during rain, ſhould conſtantly increaſe, ſo that the air muſt be enabled to retain an exceſs of moiſture. In one inſtance it is generally ſuppoſed that water is depoſited by cooling the air. No one doubts, that dew falls in the evening, from this cauſe. Yet dew is not a conſtant phænomenon: it is not moſt copious in the coldeſt evenings, or after the hotteſt days. Some other cauſe muſt therefore concur; and, though more than ſeventy years have elapſed ſince Muſchenbroeck, De Fay, and Gerſten, made experiments on this ſubject, they have been little attended to.

Dew is of three kinds, either the condenſed perſpiration of plants, the condenſed evaporation from the earth, and what has been conſidered as water depoſited in the evening, that had been diſſolved in the air during the day. The two latter appearances I mean chiefly to notice, and, if theſe are not merely depoſitions from an alteration in temperature, there will be more reaſon for ſuppoſing that water and air are mutually convertible. The aſcending dew is found to riſe to the height of 31 feet at leaſt; the deſcending dew has no peculiar region: Sauſſure perceived it on the top of Mount Blanc; and where unconfined air is found, dew is occaſionally obſerved. It is not however depoſited on all ſubſtances equally; for Muſchenbroeck remarks, as a ſingular fact, that, on a *leaden* gutter, dew condenſed on every kind of ſubſtance; on a table in the garden, it condenſed equally on bodies of very different kinds. Yet, in Germany, Gerſten obſerved that it did not condenſe on metals. At Utrecht, it falls on glaſs, china, poliſhed and *varniſhed* wood, and does not fall on metals of any kind. This appeared "confuſion worſe confounded" to the Dutch philoſopher, who made many other experiments leſs concluſive. To us, the clue is not difficult. Du Fay obſerves, that, at Paris, he put two glaſſes, like thoſe that cover the dials of watches, to receive the dew; the one placed on a metal, the other on a china diſh. The laſt collected ſix times the quantity of the former; and this glaſs, which had a metal ring round its edge, was dry near half an inch in the circumference next the ring. Dr. Watſon found in ſimilar circumſtances the aſcending dew affected in the ſame manner. Even a red wafer appeared to repel it to a conſiderable diſtance. Cold therefore is not the only cauſe of the condenſation. The change of vapour from its veſicular ſtate to that of water, is connected with the electrical principle, and all the variety depends on the poſitive or negative ſtate of the electricity of the air: At leaſt ſo much neceſſarily follows from the facts particularly aſcertained.

Miſts are generally ſuppoſed to be the condenſed fluid, which has been diſſolved in air; but theſe are leſs connected with cold than dew. The water of the miſt, like that of dew, is in the ſtate of veſicles; and ſuch is its hygrometrical affinity, that it carries the index of the hygrometer farther to the point of humidity, than even immerſion in water. Yet it ſeldom falls in rain, and is depoſited very ſparingly on the earth, unleſs on bodies adapted by their nature, or their ſurface, to receive it. On animal and vegetable fibres, it is depoſited copiouſly; and, by this, is meant the hygrometrical affinity ſo often noticed, with ſo little attention to the claſſes of bodies diſtinguiſhed by this elective attraction. On metals it is never depoſited; but the intermediate claſſes are not aſcertained with that preciſion, which enables us to determine, whether the conducting or non-conducting nature of the ſubſtance is connected with the event. From the ſimilarity of the phænomena of dew and miſt, there is much reaſon to ſuppoſe that the cauſes which influence the depoſition are not very different. But to this may be added ſome poſitive facts of importance. During the prevalence of miſts, the cork-balls diverge conſiderably, the air is highly electrical, and the electricity generally poſitive. While miſts riſe on the ſide of the hills in mountainous countries, they are attracted and repelled alternately, bounding, like white maſſes, from and towards the mountain. Theſe appearances Sauſſure obſerved on Mount Roſe; Reynier often remarks them in his Alpine excurſions; and I have more than once ſeen them near the high hills of this neighbourhood.

If, in phænomena ſo frequent and apparently ſo ſimple, the depoſition of water does not depend wholly on the change of temperature, the diminution of heat muſt have leſs effect in producing rain. The ſouth wind, which in this country uſually produces rain, is always warm; and the appearances are not thoſe which prove that humid air is wafted from a rainy region. Rain often comes on in a ſtill atmoſphere: clouds collect without motion: diſtant hills, inſtead of being ſeen in a blue glowing light, aſſume a darker hue, and neighbouring objects appear much more diſtinct: the atmoſphere becomes wet: ſmall drops are ſcattered, till they appear more collected, and of a larger bulk: the electrometer ſhows a conſiderable variation in the ſtate of the electrical fluid, and the barometer, that the quantity, the weight, or the elaſticity of the air, is greatly diminiſhed. Theſe effects cannot depend on the wind, for the moiſture of the air is perceived by hygrometrical changes, in the moſt confined room with large fire, or in the cloſeſt drawer. In either place, alkaline ſalts will diſſolve; and the barometer will ſink, with whatever care it is ſhut up. Theſe facts can only meet in one point, that air is at times converted into water, and that the electrical fluid is an agent either immediately, or remotely, connected with the change. The remarkable tranſparency of the air previous to rain, has not hitherto been noticed or explained. In that ſtate of the air, the water does not aſſume the veſicular form, nor does it yet appear like water. The rays of light thus paſs through a medium more uniform, and of courſe experience fewer refractions; beſides that, in a compound menſtruum, various ſaline and other bodies which float in dry air, and diſturb the paſſage of the rays of light, by innumerable

able reflections, are diſſolved. Theſe reaſons are ſupported by various analogies. Thus in air almoſt wholly deprived of moiſture, and attracting it from all bodies, during the prevalence of the Harmattan on the coaſt of Africa, the haze is very conſiderable: in the dry haze in this country in 1783, the hygrometer continued immoveably at the drieſt point; and hydrophanous ſtones become tranſparent on being wetted. But, from every view, the following circumſtances are incontrovertible. The moiſture is brought by no wind: the change takes place at the ſame time in every part of the atmoſphere, and moiſture is formed at once ſeemingly in every minute portion of air.

While this change of air into water explains, very ſatisfactorily, the various phænomena, we muſt not aſſent implicitly without enquiring, whether, in other experiments, it is found to take place. We have obſerved that water may be produced from air, and air again from water. In the proceſs of vegetation, this change is peculiarly conſpicuous; for plants affording copious ſtreams of pure air, may be nouriſhed by the pureſt diſtilled water. Water, expoſed to the ſun, will produce air without limitation; and it has even been analyzed into air by chemical experiments, particularly in the æolopile. Analogy would therefore lead us to conclude, that the change was highly probable; and, had no other kind of proof exiſted, the various circumſtances of theſe experiments, might have been brought together in ſo connected a form, as to have juſtified the concluſion according to the moſt rigorous rules of analogical reaſoning. This however is unneceſſary. There are deciſive experiments, that a permanent, elaſtic, aerial fluid may be produced from water in the common proceſs of evaporation.

Few are ignorant that all fluids evaporate faſter when the preſſure of the air is removed. Some bodies, indeed, evaporate only in the moſt perfect vacuum: quickſilver itſelf will evaporate in the upper part of the toricellian tube, and be condenſed at its top, where the mercury in its aſcent has never reached. In high mountains, evaporation goes on rapidly; and, when proper allowances are made, the air on mountains is drier than on plains. We may add to this, that, on the moſt accurate calculations, the quantity of water diſcoverable in a cubic inch of air by hygrometrical affinities, is very inconſiderable. Where then is the water raiſed from the earth by evaporation? What are its receptacles, or how can it be again recovered? Some experiments made by Sauſſure, with a different view, and from which he drew different concluſions, will illuſtrate this ſubject. He found, that water during its evaporation augmented the volume of air, and that this vapour was permanent, elaſtic, (Eſſais ſur l'Hygrometrie, § 190.) and in particular circumſtances, tranſparent (§ 217.). It is produced from ice; and, in the moment of congelation, its proportion is increaſed*, leſſening afterwards according to the degree of cold. This elaſtic vapour is more copious in rarefied, than in open air†; and M. Sauſſure found that,

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* Wallerius in Act. Suecicis.

† Act. Suecic. An. 1738.

when Farenheit's thermometer was at 66, the elaſticity of the air encreaſed $\frac{1}{54}$ while the hygrometer went from extreme dryneſs through $\frac{4}{5}$ of its ſcale, towards moiſture (§ 110.). When theſe experiments were purſued farther, it appeared that every grain of water became an elaſtic fluid, capable of ſupporting nearly half an inch of mercury (§ 114. 118.). The immediate concluſion from theſe laſt experiments, ſeems to be in favour of the ſuperior elaſticity of moiſt air; a concluſion apparently ſupported by the experiments of the Chevalier Andriani, who found the elaſticity of the air, in which alkaline ſalts had deliqueſced, greatly leſſened. Yet, from the whole, it is more probable that in evaporation, a permanent elaſtic air is really formed. It is at leaſt permanent in every trial which has been made; and, as it is formed at a lower temperature than that of freezing water, is certainly not to be condenſed by cold of that degree.

It is remarkable, that when air is rarefied by the pump, it appears peculiarly dry. Moiſture is attracted from all ſides, and even the water, depoſited on the internal ſurface of the receiver, ſoon diſappears, while the index of the hygrometer haſtens to the drieſt point. The elaſtic fluid, thus formed, ſoon influences the manometer, and we find an elaſtic gas produced from water, not by means of air, but from its deficiency. In the open air the production of this vapour is not equally rapid, and it ſoon eſcapes; for, as it is lighter than atmoſpheric air in the proportion of 3 to 4, it riſes to the higher regions. This newly formed, dry, aerial fluid was found by Sauſſure on Mount Blanc, by M. de Luc on the Glacier de Buet, and other mountains; and ſo powerful is its attraction for humidity in theſe elevated regions, that after the torrents of rain, which uſually fall there with violence, the hygrometer immediately haſtens towards the drieſt point. Each obſerver found alſo the moiſture leſſen during the night, while the cold was exceſſive, when, if evaporation depended on ſolution, it ought to have been again depoſited.

If then it be admitted, that water may ſometimes diſappear, in conſequence of ſolution in air, it is highly probable, from the facts already ſtated, that it may alſo become a permanent gas, unchangeable, like other compounds, except by an elective attraction ſuperior to that which unites its ingredients. Sauſſure's and De Luc's experiments ſhow that water in either ſtate does not affect the hygrometer, and this inſtrument ſeems capable of meaſuring only the water beginning to form, or beginning to ſeparate, and to point out the firſt change from the aerial to the humid ſtate. The term hygrometrical affinity therefore, as it is connected with the depoſition of the water, may perhaps be greatly influenced by the nature of the body employed, a circumſtance which has not yet obtained the degree of attention which it deſerves.

Water, in air, aſſumes alſo the form of miſt; and this has been called its veſicular ſtate. If the progreſs of evaporation be diſtinctly obſerved, it will appear, that the form of veſicles is probably in every circumſtance, the firſt ſtage of the proceſs.

It is evidently ſeen on the ſurface of rivers in a warm day, by travellers on the Alps, and on the ſteam of boiling water, which, in Sauſſure's experiments, afterwards aſſumed the form of a pure, permanent, elaſtic gas. The bulk of each veſicle, in both inſtances, is calculated to be the 3600th part of an inch; and, as the veſicles are ſpecifically heavier than air, they muſt be ſupported in the atmoſphere by the repulſive power already noticed.

The ſtriking appearances of electrical influence in the depoſition of dew, and the repulſive power of miſt, would immediately ſuggeſt the probability of electricity having a conſiderable ſhare in the different meteorological phænomena. Innumerable authors have, on various occaſions, hinted at this cauſe, but without aſcertaining the principle on which it operates, or means by which the ſeveral changes are produced. M. de Luc, whoſe induſtry is perſevering, and whoſe obſervation is acute, could not have failed in applying the facts before him, had he not been miſled by a theoretical explanation, which he ſeems to have adopted early, and truſted implicitly. He ſuppoſed, that every fluid is compoſed of a groſſer, and a more yielding ingredient; that its denſity conſiſts in the proportion of theſe component parts, and conſequently that the electrical fluid would be found among thoſe of the rareſt kind. In his diſpute with M. Libes (Journal de Rozier) he mentions the opinion I now offer, but thinks it is not to be ſupported by facts; in reality, every fact militates againſt the doctrine, if his theorem, which however is purely hypothetical, be admitted.

What authors have called atmoſpherical electricity is apparently the uncombined fluid, which floats in the atmoſphere, and, while the air is in a dry, non-conducting ſtate, does not reach the earth. In theſe circumſtances, it is conſtantly poſitive; in ſteady rain it is the ſame; but, in ſtormy weather, it frequently changes from poſitive to negative, often with ſingular rapidity, while, at intervals, no electricity is obſervable. In ſhort, if the electrometer be obſerved during a ſtorm, it ſeems to point out the various ſucceſſive changes of two ſportive contending fluids, changes which may be almoſt ſtyled the alternate victories and defeats of the ſpirits of the air. If the atmoſphere be examined during a ſtorm, alternations equally ſudden are obſervable; ſqualls and momentary calms; winds ſhifting; rain changing in its direction, its violence, and its appearance. Obſervation has not yet ſhown, that the variations of the electrical fluid always accompany theſe changes, though various facts appear to point out their coincidence.

Whatever opinion be formed of the relation or oppoſition of poſitive and negative electricity, the appearance of the former in the atmoſphere has been conſidered a problem, difficult of ſolution, and of ſufficient importance to require particular attention. That the electrical fluid may aſcend in dew and in the perſpiration of plants, will be readily admitted; but theſe conveyances can only eſtabliſh an equilibrium between the air and the earth, while the problem to be ſolved is by what means a ſuperabundant quantity of electricity is carried into the higher regions of the atmoſphere, and from what ſource the conſtant ſupply is derived. It appears to me highly probable, that the poſitive electricity of the air, which is its moſt conſtant and apparently its natural ſtate, is owing to the decompoſition of water, which, in its change into air, ſuffers the electrical fluid, ſeemingly one of its component parts, to eſcape. But this opinion muſt not reſt on ſuſpicion only.

It has been long ſince obſerved, that the ſteam of boiling water is electrified negatively, while the vapour of water poured on a hot iron, poſſeſſes an electricity of the oppoſite kind. Theſe facts ſtill appear unaccountable, and have not hitherto I believe been connected with two others, that inflammable air is conſtantly produced by water paſſing through an intenſely heated gun-barrel, filled with iron filings, and that the air proceeds from the decompoſition of the water. If then the electricity muſt proceed from a conductor or an electric per ſe, there can be little doubt of its ſource. The inflammable air may be procured alſo, if copper be employed, but in leſs quantity; and ſometimes even through porcelain though imperfectly, and apparently, in conſequence of the biſcuit containing ſome iron. With this clue let us examine M. Sauſſure's experiments particularly.

When a little water falls on iron intenſely heated, it does not immediately evaporate: like the drop of water on the cabbage-leaf, the reflection ſhows, that it is not in contact with the iron, but kept by a repulſive power at ſome diſtance. When the water is dropped into a crucible, it remains a little longer, and diſappears only after ſeveral ſeconds. The electricity is then poſitive. When the heat is leſs, the evaporation is quicker, and the electricity leſs powerful: when ſtill leſs, ſo as to occaſion a hiſſing noiſe, the electricity is negative. In porcelain veſſels it is generally negative, and in veſſels of pure ſilver always ſo.

M. Sauſſure, who relates theſe experiments, has involved the ſubject, by conſidering the diſappearance of the water as, in every inſtance, owing to its evaporation. If, as we now know, water be decompoſed, while in contact with hot iron, all the intricacy will be removed; nor can we ſpeak, with our author, of 'theſe unconnected facts, as with difficulty reconciled to the common ſyſtems, and as ſeeming to ſhrink from principles hitherto known.' The time, he obſerves, when water diſappears moſt ſlowly, is that when the crucible ceaſes to ſhine. This circumſtance would be a priori probable, if the diſappearance of the water proceeded from its decompoſition; for it is the loweſt degree of heat in which the ſeparation of the ingredients takes place, a proceſs always connected with light. At a lower degree, the water forms only veſicular vapour, and, as it is ſtill a watery fluid, no change of electricity is obſerved, or from cauſes, which it is unneceſſary to explain, the electricity becomes negative. Silver does not, in any reſpect, contribute to the decompoſition of water, and conducts more readily, when warmed, the electricity which the water might have poſſeſſed.

ſed. In an iron or copper veſſel, with a narrow orifice, the water diſappears more quickly, and the electricity is poſitive, as might have been expected from the additional heat which the water was ſubjected to. In the æolopile, water ſeems to be conſtantly decompoſed for it makes fire burn with an enlarged and more brilliant flame; a proof of the preſence of a pure elaſtic fluid, whoſe exiſtence and whoſe ſource has not hitherto been ſuſpected.

M. Sauſſure is equally perplexed by the reſult of other experiments, which the ſame explanation will reconcile. He was greatly ſurpriſed to find electricity only in boiling liquors, not in burning bodies. It is well known, that after the moſt careful diſtillation, the whole of the water cannot be recovered, and it is equally certain, that ſome water is formed during the burning of every vegetable ſubſtance. The electricity therefore eſcapes, in the firſt inſtance, on the decompoſition of the water, and is combined with the water in the ſecond.

It is now admitted that water is decompoſed in the proceſs of vegetation, and in various inſtances we have diſcovered marks of the eſcape of the electrical fluid. The motions of the mimoſa are known to depend on electricity; various plants have been found to ſparkle with electricity; and the colour of vegetables, ſuppoſed to be owing immediately to light, is now diſcovered to proceed from the inflammable air of the decompoſed water, for the light acts only as the irritating principle, or as a component part in the flouriſhing plant. Without light the mimoſa no longer ſhrinks from the touch, the calendula furniſhes no ſparks, and the hediſarum gyrans is ſtill. The inflammable air alone is rendered ſenſible in our chemical decompoſition of vegetables; but this aerial fluid, united with light, is intimately connected with electricity. Kirwan, Prieſtley, Lavoiſier, and Sauſſure, ſeem to think the electrical fluid compoſed of theſe only; for the electrical ſpark, frequently paſſed through common air, greatly diminiſhes its bulk, and renders it inflammable, while light alone eſcapes. In this experiment, the electricity is loſt, and in long circuits, particularly, if various junctures require numerous minute exploſions, the electricity diſappears, (Prieſtley & L'Epinaſſe Philoſ. Tranſ. v. 57. p. 186.). In the ſhocks received by the human body, when on an inſulated ſtool, the electricity is loſt or deſtroyed; nor when a highly charged cloud burſts on ſome elevated part of the earth, and reſtores the relative æquilibrium, is it certain, that the balance is owing to the earth's having acquired more electricity, rather than to the cloud's having loſt its ſuperabundant proportion.

In atmoſpherical phenomena, we find various proofs of electricity proceeding from the decompoſition of water, and again diſappearing on its formation. Signors Volta and Beccaria found the foggy vapours which ariſe in the morning without any marks of electricity; but when they began to diſappear, the electricity was very ſenſible, and became poſitive. When clouds form in a ſerene ſky, Beccaria found the electricity diminiſhed; and it became ſenſible again when the clouds diſappeared. This laſt change appeared ſo ſtriking, that he calls it electricita di raſſerenamento. M. Lullin made a very ſingular and curious remark. A pole was fixed in the ſide of a mountain, extending beyond it; when light clouds aroſe to the height of its extremity, and diſappeared, the pole was electrified; but when they remained in maſſes, and enveloped the mountain, no electricity was obſerved.

Though the air on mountains is dry, and highly electrical, the formation of ſteam is ſlow, and the time required to bring fluids to a boiling ſtate longer, notwithſtanding the temperature neceſſary for ebullition is lower. It ſeems as if fluids, in theſe ſituations, more readily aſſumed the form of air than of ſteam, to which the heat, neceſſary to form veſicular vapour, readily contributes. In elevated ſpots fire does not burn with rapidity, for the air is greatly contaminated with the hydrogen from the water, and is alſo very rare. To this ſtate the debility felt on very high mountains may in a great degree contribute.

Modern philoſophers have endeavoured to aſcertain the altitude moſt conducive to health, and have fixed it, for reaſons not fully explained, at 2400 feet above the level of the ſea. It has been determined, with more certainty, that the moiſteſt region of the atmoſphere, or the height to which vapours, either not diſſolved, or not converted into air, moſt commonly riſe, is about 1600 feet above the ſame level. But when we ſee water, converted into air, riſing from its levity to the higher regions, a levity eaſily accounted for by the proportion of inflammable joined to the vital air, and find the upper regions chiefly contaminated by the former, we ſhall, with greater probability, fix the moſt healthy region below, or a very little above that of the watery clouds.

If we examine the progreſſive ſtate of atmoſpherical electricity, we ſhall find it intimately connected with the ſtate of water in the air. Aerial electricity has its diurnal and its annual revolution. It daily ebbs and flows, like the tide, following, in ſome degree, the courſe of the ſun.

In ſummer, when the ground is dry, and the air ſerene, the electricity increaſes from 4 in the morning, or more nearly the riſing of the ſun, till 3 or 4 in the afternoon: it then diminiſhes gradually till the falling of the dew, when it increaſes, again to diminiſh, and to become almoſt inſenſible, at 4 the next morning. This is the progreſs it would have, if connected with the decompoſition of water: thus we find the hygrometer little affected at 4 in the afternoon, and the moiſture greateſt from 8 or 9 in the evening, to 4 in the morning. When the earth is wet, its progreſs is very different, and that this difference depends on the moiſture is certain; for, when fine weather, in ſummer, ſucceeds continued rain, the electrical variations are in the ſame order as in winter. It is then greateſt at 9 in the morning, and diminiſhes gradually till 6; it increaſes till 8, and diminiſhes till 6 o'clock the next morning. This is not eaſily explicable without the hygrometer, which follows, at theſe periods, nearly the inverſe ratio, for it points to the greateſt moiſture, when the electricity is leaſt, and the contrary.

The annual variation equally confirms the ſyſtem. Electricity decreaſes from November to March: it increaſes gradually from March to September. It decreaſes in the dampeſt period, and increaſes as the air is drier.

The diurnal variations of the barometer on the mountains are equally deciſive; and I ſelect the obſervations on theſe, as, in the valleys, various exhalations may contribute to raiſe the mercury. We there find the mercury loweſt at 8 in the morning, the period at which the newly formed air can ſcarcely be expected to have aſcended; and higheſt at 2, when the evaporation has had its fulleſt effect.

Theſe remarkable coincidences between the appearance or diſappearance of electricity, and ſerene or rainy weather, lead me to conclude, that the electrical fluid is an important agent in the ſeveral changes. From theſe alſo it appears probable that the electricity is combined with the water, and conſequently all the difficulties, that have embarraſſed M. M. Sauſſure and De Luc are avoided. I aimed at no more than to connect the facts; for to explain all the appearances which may reſult from them, would require a volume; to point out the means by which the union and ſeparation are effected, demands a much more extenſive knowledge of the properties of theſe ſubtle fluids, than we at preſent poſſeſs.

Rain however occurs in particular circumſtances, where the uſual cauſes can have no influence, where the connections already aſſigned ſeem not to exiſt. When the wind blows from any point of the eaſt, the rain which accompanies it, is eſſentially different, in its appearance, from what has been already deſcribed. Inſtead of a ſky uniformly dark and gloomy, low black clouds, interrupted with brighter ſpots, give the deluſive promiſe of fairer weather. In theſe circumſtances, the rain often comes on unexpectedly thick and heavy; while, at other times, tho' the clouds are apparently lower, and the ſky more uniformly gloomy, rain does not fall. The barometer is ſeldom affected; and every common ſign of impending rain is either not obſerved, or fails in the event; the hygrometer points to its drieſt point, the electrical machine acts imperfectly, and there is little uncombined electricity in the higher regions of the atmoſphere. The dryneſs of the air renders it capable of abſorbing the moiſture of the earth, yet during eaſterly winds evaporation is neither general nor rapid. In other reſpects, it is unfavourable to vegetation, injurious to health, and unpleaſing from the feelings it imparts, as it is ſharply and uncomfortably cold.

The ſuſpicions offered to your notice in this eſſay, will contribute to explain ſome of theſe peculiarities. The air, loaded with water, has abſorbed the uncombined electricity of the atmoſphere, and the veſicular maſſes of clouds appear to be repelled from the earth, occaſioning the appearance of more radiant ſpots, till the ſurcharged cloud again approaches, and is again repelled. I have not been able to explain, what occaſions the formation of water in the air to admit of its falling in rain at any time, and have conſequently not aimed at giving the theory in a more ſatisfactory form. It is no diſgrace therefore to leave what has appeared to all meteorologiſts the moſt ſingular anomaly, in its former obſcurity.

The dryneſs of the eaſterly wind ſeems to ariſe from the hygrometrical affinity of the earth, for it is not favourable to evaporation in general; effects by no means contradictory, ſince from evaporation the uncombined electricity would be ſupplied. Exceſs or defect of this fluid in the air, appears equally injurious to animal life; for previous to hurricanes in the Weſt Indies, when the air is highly electrical, the health of the inhabitants is greatly injured; and Swinburne remarks, that during and after the fatal earthquake in Calabria, ſcarcely an inſtance of miſcarriage occurred, an event otherwiſe very uſual in that country.

Though, in this way, we approach nearer to the explanation of a problem uſually conſidered as inſoluble, I cannot help adding,

ing, that I think theſe ſuggeſtions very unſatisfactory; and, while the electrical fluid performs ſeemingly ſo important an office in meteorological phænomena, it muſt be remembered, that it is a compound, and that the union of its ingredients may be deſtroyed; but this is untrodden ground, and I have carefully avoided the flowery but deluſive paths of conjecture. The compoſition of the electrical fluid is not yet properly aſcertained: it is not yet known whether it is ever loſt in its circuit; whether its activity contributes to its deſtruction; or whether the light which it diſplays is an eſſential ingredient in the compoſition.

When we contemplate the ebbs and flows of agents ſo powerful and active, a ſuſpicion will naturally ariſe, and we may be tempted to aſk, whether other periodical phænomena may not have a ſimilar origin. The cauſe of the regular ſwell of the ſea is generally ſuppoſed to be the attraction of the ſun and moon; and it is commonly admitted, that this attraction acts immediately on the waters of the ocean.

The opinion was firſt ſuggeſted by Kepler, and explained ſhortly and comprehenſively in the earlieſt edition of the Principia. Newton was followed by Euler, Daniel Bernouilli, Maclaurin, and Clairaut, who were competitors for the prize offered by the French academy on this ſubject. Maclaurin demonſtrated, that a fluid ſphere acted on by powers proportional to the diſtance from the axis, would aſſume the figure of an elliptic ſpheroid; and Clairaut extended the propoſition to a ſphere not homogeneous. Yet each ſuppoſed the ſphere compoſed of parts moving on each other; and, in this enquiry, as well as the inveſtigation of the cauſe of the ſpheroidal form of the earth, the body muſt be capable of admitting a change of figure in all its parts: the change muſt alſo be gradual and progreſſive. Thoſe authors who ſuppoſed the change of figure in both theſe inſtances as a ſimilar effect, ſeem to have overlooked an eſſential diſtinction. Attraction is a ſimple power, acting in ſtraight lines, or from the effect of different forces in a diagonal line. The direction of the centrifugal

trifugal force is in the tangent of a ſphere, and it is, in reality, communicated motion in a direction different from that of the body which impells.

This defect in the firſt ſtep of the proof, is not leſs conſpicuous than a difficulty in its progreſs. If, as the Carteſians have already remarked, the ſea is raiſed by attraction, why ſhould the waters riſe on the oppoſite ſide, where the attraction is confeſſedly diminiſhed? The reply has been, that when the waters are raiſed by the attraction, the centre of the earth is drawn alſo nearer to that ſide, and the waters of the antipodes, now at a greater diſtance from the centre, riſe from a deficiency of the uſual attracting power. The explanation is however only applicable to a ſphere whoſe parts move freely on each other, and, if the authors had ſaid "centre of gravity," it would have been more conſiſtent with the properties of a denſe planet. But, if centre of gravity were ſubſtituted, it would not contribute to the explanation, ſince no cauſe is aſſigned why the balance between the different parts of this globe ſhould be preſerved by this, rather than any other mode. To which may be added, that the denſity of the earth at its centre, will occaſion very little difference in the ſituation of the centre of gravity from the partial and unequal riſe of a fluid ſo light as water on its ſurface. If, as has been aſſerted, the attraction of the ſun and moon acting in an oppoſite direction to that of the earth, and leſſening the attractive power of its centre, ſhould cauſe the waters to ſwell in the zenith, they would ſwell alſo in the nadir, from the deficiency of attraction. In that caſe, the riſe of the waters would be only in the ratio of the difference of attraction; and the calculations of the abſolute force of the attraction muſt fail.

The calculations are not however ſupported by facts, nor are the facts conſiſtent with the general theory. From calculation, the ſea ought to riſe, where not impeded by obſtacles, eight feet; but in the Atlantic and Pacific Oceans, it ſcarcely riſes three feet. Near the ſhore, the tides are higher, and theſe are accounted for by the reſiſtance the earth gives to the expanſion. The reaſon might be admitted, if the ſea, when uncontrouled, roſe to its proper height; but the fact requiring an explanation is, why the tides do not anſwer to the calculation when no obſtacle is oppoſed.

The Mediterranean, a large expanſe of water, does not riſe or fall, or ſwells only in a very inconſiderable degree. M. de la Lande has indeed demonſtrated a propoſition of Bernouilli, that the height of the tides in ſeas is proportional to their longitude; but the propoſition does not apply to the Mediterranean, which is continued in longitude with the Atlantic by the Straits; nor does the degree in which the tides really riſe correſpond with its own extent in longitude, when the various local obſtacles are alſo taken into the conſideration. At the Straits, the tides are conſpicuous: they are conſpicuous alſo at the bottom of the Adriatic, perhaps influenced in part by the current; but theſe various anomalies are not eaſily reconciled to the cauſe, almoſt excluſively aſſigned for tides, the attraction of the ſun and moon.

To have enlarged on the inſufficiency of former theories, without being able to ſuggeſt a more ſatisfactory explanation, will require ſome apology. But I ſhould not have engaged in the enquiry, were it not to hint, that, though the ſun and moon ſeem certainly to occaſion the alternate ebbs and flows of the ſea, yet the more immediate cauſe appears to be a variation in the height, and conſequently in the preſſure of the atmoſphere. It muſt be remembered, that the greateſt height of the tides is ſucceeded by the loweſt ebbs; that the greateſt ſwell is not in the moment when the power of attraction is greateſt; that high winds, which certainly proceed from partial vacua in the air, will greatly increaſe the height of the tides. If the earth, ſurrounded by its atmoſphere, be for a moment conſidered as a ſpheroid of which the terrene part is an immoveable nucleus, the whole theory of attraction, as applied to the parts ſurrounding the nucleus, will be encumbered with fewer difficulties: Yet thoſe which remain will be numerous, and will not probably be ſolved, till the phænomena of tides be more accurately inveſtigated. Their cauſe has been ſuppoſed well known, and the circumſtances accurately underſtood; ſo that enquiry has been for many years at an end, and obſervers have been inattentive.

A few reflections, in concluſion, may not be unſuitable.—To many philoſophers, diſtinguiſhed for the extent of their knowledge, and penetration of their judgment, the Moſaic account of the deluge has appeared a correct and philoſophical narrative of the progreſs of this planet from a ſtate of chaos to its preſent harmony. Every late diſcovery confirms this opinion; and, if air and water be mutually convertible into each other, a deluge, whether univerſal or local, will not be a problem ſo difficult as has been generally ſuppoſed. If the quantity of air over any one ſpot were converted into water; if the air which covers the ocean were equally changed, the one would deluge the earth, and the other burſt its cearments. "The fountains of the great deep" would be ſeemingly "broken up," and the water would cover the higheſt mountains; while thoſe who were preſerved would only feel the changes which every traveller who has aſcended the higheſt mountains muſt have experienced. If the ſubject be examined in its full extent, ſome conſiderable general convulſion will appear eſſentially neceſſary in the progreſs from chaos, to harmony, to order, and that balance in the ſeries of cauſe and effect, which can only enſure a permanent arrangement.

If the ideas which I have endeavoured to ſupport in this eſſay be true, they will contribute to explain the different circumſtances which occaſion the riſe and fall of the barometer. Little has been ſaid of former ſyſtems in this eſſay, and of courſe, the various and diſcordant opinions of philoſophers on the ſubject need not be repeated.—The lateſt explanations are thoſe of De Luc and Pignotti, but theſe are perplexed with difficulties; and I hazard little in adding, that neither ſyſtem is ſupported by obſervation or experience. The barometer, I have already obſerved, is a complicated inſtrument. It in ſome meaſure points out the elaſticity of the air, but, in the higher regions, chiefly its weight. As a *mano*meter, it muſt be corrected by the temperature of the atmoſphere, and from this circumſtance ariſe the various ambiguities in its predictions of the weather. Like the oracles of antiquity, it is ſometimes myſterious, and ſometimes deceitful. As a *baro*meter, ſhowing the actual weight of the air, it is influenced by the changes mentioned; for when rain is impending, the elaſtic vapour is aſſuming the form of water, and the real height of the atmoſphere greatly diminiſhed. The height of the clouds is various: they are bodies of veſicular vapour; and, from a calculation of their comparative denſity, are capable of riſing occaſionally to the height of 13,500 toiſes, exceeding 16 miles.

This ſyſtem alone explains why high

winds ſhould affect this inſtrument. Winds can never occur but to reſtore the equilibrium of the air, and the equilibrum cannot be deſtroyed, but by cauſes diminiſhing the weight of the atmoſphere at one place. This was the chief difficulty in the theory of winds. Rarefaction, by heat, could effect it but ſlowly, and the return muſt be gentle and gradual, ſuch as we find the recurrence of the ſea-breezes in the iſlands between the tropics. The cauſe was however inadequate to the explanation of violent ſtorms, and no other has been ſuggeſted. But if air be decompoſed, and if the decompoſition be ſudden, we can have little difficulty in explaining the cauſe of the violence with which the air around reſtores the equilibrium, or the reaſon of the barometer ſuddenly ſinking. I remember, about the time when the earthquake happened in Calabria and Sicily, which deſolated that fertile, but devoted country, I was in the habit of examining the barometer, to adjuſt the ſcale of one which I had made. I ſaw the mercury ſink very rapidly, far below the point to which it commonly falls in this country. I expected a violent ſtorm, and predicted it. But a ruffling wind with a peculiar appearance of the clouds only followed. On examining the journal, this low ſtate occurred the day *after* the violent earthquake; and the air ruſhing in to ſupply the vacuum, even left the other parts of the atmoſphere deficient, as the wave, which fills the hollow left by his predeceſſor, forms a ſimilar vacuity behind it. A ſimilar fall of the barometer occurred at Durham; and a gentleman, acquainted with Naples, told Mr. Swinburne that an earthquake had probably happened about this period in a more ſouthern region.

Some other concluſions and reflections might be added; but theſe are ſufficient to enforce the importance of inquiries on the grounds I have ſtated and endeavoured to eſtabliſh. Should the foundation be found unſtable, I ſhall readily reſign the ſuperſtructure, wiſhing only to aſſiſt the progreſs of ſcience by marking ſome relations, which others might have overlooked, and collecting facts, which, widely diſperſed, and hitherto careleſsly preſerved, might have been neglected or forgotten.

——— "fungar vice cotis, acutum
Reddere quæ ferrum valet, exors ipſe ſecandi."

September 25th, 1794.

SIS.

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OBSERVATIONS on LIGHT,

Particularly on its Combination and Separation as a chemical Principle.

— — — — — ex fumo dare lucem
Cogitat. Horat.

If in the firſt ſtep of this enquiry, it be aſſumed, that Light is a body conſiſting of material particles of ſingular tenuity, moving with inconceivable ſwiftneſs in ſtraight lines, the principle will receive ſufficient ſupport from the arguments of Newton, various aſtronomical obſervations, and Dr. Bradley's very ſatisfactory explanation of the apparent aberration of the fixed ſtars. The oppoſite ſyſtem of Euler formerly occaſioned a controverſy which has now ſubſided, and philoſophers have acquieſced, with few exceptions, in the opinion of his antagoniſts. We can admit, that rays of light are interrupted in their progreſs by air, that they mutually impinge on, and change each other's direction, for M. M. Bouguer, Sauſſure, and Thompſon, have demonſtrated that nearly one half of the light of the ſun is loſt in paſſing thro' the lower part of the atmoſphere; that its effects are proportionally diminiſhed; and that images, perceived by reflection, are clear and diſtinct, though one-third of the light is loſt by unavoidable imperfections of the mirror. The immediately ſucceſſive impulſe of luminous particles is by no means neceſſary to viſion, ſince the retina for a time retains impreſſions once received; and M. d'Arcy has computed, that the ſenſation is diſtinct, though each atom of light be more than 27,000 miles diſtant from that which ſucceeds.—In ſhort. "a body whoſe motion we can perceive, whoſe velocity we can calculate, whoſe direction we can change, which we can accumulate and diſperſe, whoſe conſtituent parts we can ſeparate and reunite, which we can combine with, and ſeparate from other bodies, muſt be a ſubſtance peculiar and diſtinct." (Macquer).

Light probably conſiſts of atoms or particles darted from their ſource with different velocities; for to employ the term rays, would imply rectilineal bodies, an idea adopted probably from the appearance of light, when ſeen to paſs through a ſmall aperture, and fixed in the mind, by the diagrams of optical writers, without adverting to mathematical diſtinctions. No phænomenon ſupports this idea; and, if light conſiſted of faſciculi of any aſſignable length, the objections of Euler would receive additional force, and the diſtance compatible with ſenſation, between ſucceſſive particles, muſt be eſſentially varied.

Though luminous particles are apparently very minute, yet from different experiments, they appear ſuſceptible of attraction, when paſſing through tranſparent media, and of being diverted from their courſe, when paſſing by the edges of thin bodies. Numerous phænomena ſeem alſo to require the admiſſion of the hypotheſis, that one ſide of the atom is differently affected by the power of attraction from the other; ſo that ſuppoſing the particle originally globular, it will be projected, after paſſing through a refracting medium, into a parallelogram, rounded by an imperfectly defined circle. The coloured ſpectrum, in conſequence of the refraction of light through a priſm, is of this ſhape, and it leads to a ſuſpicion, that the luminous globule is expanded only, and becomes coloured in conſequence of attenuation. This ſuſpicion derives ſome ſtrength from various other facts: light, for inſtance, paſſing through air, in very minute maſſes, appeared, in Sir Iſaac Newton's experiments, to be coloured; and, when broken and divided by paſſing over the edges of thin bodies, it aſſumes the appearance of a coloured fringe connected with the body. The colours exiſt only in our minds; for the light, thus divided, has no diſtinct effects in its different parts, and appears, in every experiment, to be light only of different intenſities.

tenſities. Phoſphoric bodies, when made to ſhine by coloured lights, do not aſſume the different colours to which each is expoſed; and when they appeared to reflect the peculiar light in Beccaria's firſt experiments, it is generally ſuppoſed that he was deceived by an optical illuſion, for no one has ſince been able to repeat them with ſucceſs. In the ſynthetical experiment of the coloured card, the colours confound each other, but the reſult is a browniſh grey, like the atmoſpheric glow; and we are informed by painters, that the union of the different primary colours is requiſite to produce an imitation. The imperfection of colours will indeed prevent us from being perfectly ſucceſsful in the experiment; and this argument might be admitted, if other forcible facts could be adduced in ſupport of white being the reſult when the different colours of the ſpectrum are united.

Of thoſe colours into which each globule is apparently divided, blue ſeems to be light in its pureſt and moſt active ſtate, for the light which has formed a component part of bodies aſſumes this colour: blue produces the effect of the undivided light in vegetation, and in deepening the colour of different woods more perfectly than light of any other colour; blue light will ſometimes impart its own colour to phoſphoric bodies, blacken luna cornea, and give the peculiar red to the ſtalks of the ſpinage *; while Mr Wilſon's phoſphorus, whoſe light was red, could not be made to aſſume its diſtinguiſhing colour by being expoſed to red rays, the more active light of blue was eſſentially requiſite. In the changes produced on acids by the addition of light, the firſt portion produces an orange, and only after a longer period the green and the blue appear: the progreſs of the colours is inverted in the oppoſite proceſs. The blue rays produced a change in the colour of luna cornea in fifteen ſeconds; the red required twenty minutes; and, even after this period, the change was leſs conſiderable.

Light ſeems to be impelled with different velocities, according to its ſource, and the rapidity of its ſeparation. The velocity

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* Sennebier.

city and impulſe of light from the ſun has been often calculated ; its rapidity repreſſes every fainter illumination, for it repreſſes the ſeparation of light from inflammable bodies, and conſequently impedes combuſtion. There are ſome lights viſible only in the dark, becauſe they are not expoſed to this counteracting impulſe, and are only perceived by eyes for a time diſuſed to the more violent impreſſions ; but there are probably inſtances of a ſeparation of light, whoſe impulſe is not ſufficient to penetrate the cornea, for effects, uſually the conſequence of its preſence, are ſometimes perceived where no illumination can be obſerved. It is enough, however, to mention the probability of the fact, which muſt be admitted with caution, as it is at preſent without any very deciſive argument in its favour.

Solar light ſeems to dart through the air with rapidity, and in no inſtance to combine with the atmoſphere, or any other gas. We ſeem to perceive light in the air, by no means air enlightened; for, in every inſtance, illumination requires reflected or ſeparated light. The ſimpleſt example of the latter is the light imbibed by phoſphoric bodies, and ſeparated without any change in their texture, or their chemical nature. After having been expoſed to the light, they appear luminous in the dark, for a time proportioned to the period of their expoſure. This property, which is very extenſively diffuſed, proves not only that light is a body, but, though active in its nature, compoſed of parts mutually repulſive, and generally ſo active in theſe repulſions, as to be projected in ſtraight lines to immenſe diſtances, it may yet become latent and quieſcent. The light imbibed by a diamond brilliantly phoſphoric, was preſerved for ſix months without any diminution, by covering it with black wax. (Du Fay).

Various facts ſhow that light may combine with, become a component part, and give new properties to bodies in conſequence of a permanent union. It blackens the oxyds of ſilver, of mercury, and biſmuth, whitens the ſulphurated calx of antimony, (Sennebier); reduces the calces of ſilver and of gold *; gives the purple colour to the juice of the murex; the violet to the decoctions of archil and trefoil; the red fumes to the nitrous acid; and when ſtrong, or long continued, will even deſtroy the phoſphoriſm of phoſphoric bodies. Light will expel the vital air from the oxygenated muriatic acid, and, in this operation, which heat alone will not effect, and which cold even ſeems to aſſiſt, (Sauſſure and Sennebier), the acid is changed in its properties and affinities. The experiments of Sauſſure, made on the Col de Geant, with the comparative trials of his ſon at Chamouni, have placed the concluſion beyond a doubt, (Turin Tranſactions), for the expulſion of the air was more complete in the exact proportion of the different intenſities of light; nor can it now be objected, that it does not expel vital air from the oxygenated acid of ſulphur, ſince M. Giobert has found, that the manganeſe is united with the acid, in the proceſs, which immediately abſorbs the vital air, as ſoon as it is formed. (Turin Tranſactions).

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* Scheele on air and fire.

In other inſtances, light expels vital air, and gives colours and properties to the new compound. Animals confined in obſcurity become white, from the arctic bear to the larvæ of the minuteſt inſects; and when the latter are compelled to bear the light of the ſun, they become brown: the tree-frog alſo, brought from its dark receſs to a more enlightened habitation, changes from a dirty yellow colour to a dark green. Water, we have ſeen in a former eſſay, is not decompoſed without the aſſiſtance of light; and whatever violently attracts or expels vital air from water, will produce a decompoſition: light in the proceſs of vegetation, and liver of ſulphur, in a ſtill ſhorter period, (Deiman, Paets, &c. dans le Journal de Rozier, Tom. 42. P. 31.), produce the ſame effect.

The effects of light on plants form a more extenſive ſubject of conſideration; but they will be found conſiſtent with the other phænomena. The direction of the flowers and leaves of plants towards the ſun is well known to be the effect of light, and this property is ſo univerſally diffuſed through the whole of the vegetable kingdom, that every plant may be ſtyled, with propriety, an heliotrope. The blanching of plants is well known to be the effect of ſecluſion from light; and the Abbé Teſſier, by varying the experiments, has found that the green colour is owing to light acting *on* the vegetable, and its degree to be in proportion to the intenſity of the light, (Memoires de l'Academie 1783). Theſe facts, connected with the obſervations of plants expiring vital air, may be thought ſufficiently deciſive; but it is neceſſary, from more recent experiments, to purſue the enquiry farther.

The moſt modern ſyſtems ſuppoſe that water abſorbed by the roots of a plant, is conveyed to the extremities of its leaves by a power, either vaguely attributed to capillary attraction, or more pointedly referred to irritability, where, by the action of light, it is decompoſed. The oxygene of the water is ſuppoſed to be diſcharged as excrementitious, and its inflammable air to be united with the plant. It is not generally known, that every vegetable will not grow in the dark; that every plant does not breathe vital air; that the leaves of ſome are naturally white; and that others are green in the darkeſt ſituations. Theſe apparent exceptions, which ſeem to deſtroy the whole ſyſtem, will appear, in reality, its beſt ſupports, if they are found to depend on the ſame principle, differently varied, on the ſame effects produced by different agents. Light is indeed the irritating principle of plants, the means by which their circulation is carried on, for their functions are connected more with the ſerenity of the ſky, than with the temperature (Guetard ap. Sennebier, Mem. Phyſico-Chemiques, v. 2d); and, while light, by decompoſing water, leſſens the reſiſtance above, the irritability, aſſumed by M. Girtanner, is as unneceſſary for the continuance of the motion of the fluids, as it is contradicted by the anatomy of a vegetable, which ſeems to poſſeſs no veſſels, but the ſpiral ones, containing air only. The change is probably produced in the leaf, and perfected only at its margin,

gin, or its extremity, for, when blanched vegetables are reſtored to the light, the green colour firſt appears in theſe parts; and plants, which have been for a time confined to obſcurity, contain water in a proportion unuſually large. This is the ſimpleſt view of the œconomy of vegetables; and, ſo far as it extends, it is complete, for the hydrogene of the water, united to the light, forms the reſinous ſubſtance, which exiſts in a ſmall quantity in plants nouriſhed by water only; and M. Fourcroy alſo found, that plants yielded oxygene in proportion to their green colour. When plants grow in the earth, they there find the carbone of the French chemiſts, the baſis of fixed air*, which, taken up with the water, is conveyed to the extremities of the leaves, and adds to the quantity of oil and reſin. The baſis of the fixed air, uniting with the inflammable air of the water, produces oil, which, with additional oxygene, forms a reſin, (Haſſenfratz An. de Chym. xiii. 318). This new ingredient leſſens the apparent quantity of oxygene, for a part of it ſometimes forms fixed air; and, in gloomy days, when the decompoſition of water is not rapid, and at nights, when it is partly checked, the exhalation of vegetables conſiſts of fixed air only. From the reſinous ſubſtance, thus formed, the ſplendour of the colours in the flower-leaves, and the various hues of fruits, proceed. Spirit of wine ſometimes diſſolves the reſin, and preſerves the colour; but it is deſtroyed by the ſun's light, while the coloured aqueous ſolutions are uninjured, when joined with acids. It is moſt probable, therefore, that in theſe inſtances alſo, the oxygene is expelled by light, and the reſinous ſubſtance deſtroyed: the acid preſerves the colour, becauſe it ſupplies by its own decompoſition the vital air.

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* The principle by which different manures fertilize the ground, is yet obſcure. The ſcattered obſervations meet however in one point; for all manures contain fixed air, or greedily attract it.
Haſſenfratz A. de Chym.

If light is chiefly uſeful in ſeparating vital air from the decompoſed water, other agents may ſometimes ſupply its place. Phlogiſticated and inflammable air will produce the ſame effect; and, when we ſee various plants and moſſes, particularly the poa annua and compreſſa, the plantago lanceolata, trifolium arvenſe, cheiranthus cheiri, the lichen verticillatus, and another moſs yet imperfectly deſcribed, of a green colour, tho' growing in the galleries of mines, where a ray of light does not penetrate, we may reaſonably attribute their verdure to the gaſſes juſt mentioned, which abound in theſe regions, (De Hombolt ap. Rozier). The azote and hydrogene ſupply the place, or increaſe the effects of light. In Sennebier's experiments, they ſupplied its place, and M. Ingenhouz found a little inflammable air, joined with the vital, increaſe the green colour, when growing vegetables were confined in theſe gaſſes. The Count de Morozzo (Turin Tranſactions 1786-7) diſcovered plants in marſhy ſituations whoſe leaves were covered with a brown powder, which produced fixed and inflammable air; the leaves were of a colour unuſually deep, and thoſe of the ſalix viminalis, which was particularly examined, were highly inflammable.

mable. In ſome inſtances, the oxygene is retained, and, in others, expired in a new form. It is retained in many pale acid plants, where, with the carbone, it produces the acid: in various lichens, in the byſſus lactea, &c. it ſeems to be retained, and they are found of a whitiſh colour, highly inflammable. Sometimes, joining with the hydrogene, it is expired in the form of an inflammable gas, as in the flowers of the fraxinella, many of the fungi and byſſi; ſometimes with ſulphur, in that of an hepatic gas. In the cedar, the oak, the white beech, &c. the oxygene ſeems to be in part retained, for what is expired appears in the form of fixed air only, and we find a larger proportion of oxygene in their reſins and aſtringent juices. Phlogiſticated air is another form in which the oxygene is ſometimes diſcharged, but we are unacquainted with its baſis, except as an ingredient in animal ſubſtances, where it is conſtantly found, and is their diſtinguiſhing chemical principle. The mimoſa is chiefly diſtinguiſhed by its phlogiſticating the air, and, as it agrees with animals in this principle, ſo it agrees with them alſo in poſſeſſing irritable fibres, and in its affinity to the electric fluid. But we require a more particular knowledge of the baſis of the azote, to explain its ſource in the expiration of the mimoſa, and a few other plants. Red leaves of plants reſemble the leaves of blanched vegetables: they are uſually the appendages of acid plants, they ſeem to poſſeſs no circulation, and afford no air from the red points. In plants of this kind, the points of the leaves are uſually green.

We find then that, in all the various facts hitherto obſerved reſpecting the growth of plants, the ſame principle pervades the proceſs, and the action of light generally ſeparates the oxygene, which, though diſguiſed, may be ſtill traced; and, when not diſcharged, leaves diſtinguiſhing marks of its being retained, often of the cauſe of its retention. The impulſe of light however penetrates farther than, at the firſt view, may be ſuſpected. We know that it penetrates the buds of the more brightly coloured flowers, which are found ſomewhat varied in their hues, prior to their expanſion. M. Bonnet has obſerved its effects through many folds of paper; M. Sennebier has perceived its peculiar changes through many ribbons, even through the epidermis and bark of trees, and we ſhall find that, as it evidently penetrates the cornea, ſo its influence extends through the cuticle and ſkin of the human body. It is remarked by the Abbé Teſſier, (Memoires de l'Academie pour 1783), that potatoes, when guarded carefully from every ray of light, mix their roots and young branches indiſcriminately; and M. Fougeroux de Bondaroy perceived the ſame confuſion among the ſhoots and branches of the Indian cheſnut, in a ſimilar ſituation. In foreſts, the ſuckers often paſs laterally through the earth, till they reach the open air, and feel the effects of the ſun, at the edges of the plantation; and light ſeemed alſo to M. Sennebier peculiarly requiſite to the early vegetation of French beans, for, when tranſmitted through coloured glaſs, their appearance was conſiderably retarded. It is highly probable, therefore, that the influence of light reaches beyond the ſurface of the earth; and, though this element in its active ſtate muſt ſoon be loſt, yet the chemical changes which it produces, may influence the inferior ſtrata. If the electrical fluid is only a more active form, or a peculiar modification of light, an eaſy communication is opened for this ſubtle fluid to any depth, at which water from the atmoſphere can penetrate. We ſee the effects of light on a fertile ſoil, in many inſtances; the earth from deep cellars is unfit for vegetation; the good effects of fallowing proceed in a great meaſure from expoſure to light; and we ſhall probably find, that this element contributes eſſentially to the formation of nitre. We know alſo that light is capable of combining with one of the ingredients of every rich earth, viz. aerated lime. The phoſphoriſm of this ſubſtance has been illuſtrated by many chemiſts in the Annales de Chymie, and particularly by M. Dolomieu, (Journal de Rozier, Année 1792): a ſingular inſtance of its containing light, as a component part, was obſerved by M.

Sennebier, who ſound both the calcareous earth and magneſia capable of blackening luna cornea, a property confined excluſively to inflammable ſubſtances and light. Nor is this circumſtance peculiar to our planet, for the illumination, that remains on the moon in a total eclipſe, cannot, in Mr. Herſchell's opinion, be wholly aſcribed to the light which may reach it from the refraction of the earth's atmoſphere; and the faint illumination of the unenlightened part of Venus, as it does not ariſe from a ſatellite, according to the ſame author, is probably owing to ſome phoſphoric quality of the planet, or ſome luminous decompoſitions in its atmoſphere.

In theſe inſtances of its combination with the earth, there is no evidence of its expelling vital air; yet, in every fertile ſoil, this principle is ſcarcely perceptible, except in the very ſmall proportion of manganeſe or of lead, in a calciform ſtate, which it may contain, and from neither of theſe ingredients is the earth ſuppoſed to derive any advantage. From the effects of light in another way, the ſoil may be benefited, though probably in no very conſiderable degree. It has been found by M. M. Lavoiſier, Petit, Chaptal, and Dorthes, to aſſiſt the proceſs of cryſtallization, and to be eſſentially neceſſary to that beautiful form of cryſtal, which many ſalts aſſume, called arboreſcence, from the varied ramifications. The force with which the minuter molecules of ſalts ſhoot into cryſtals, is well known often to break the chemiſts glaſſes (Vauquelin An. de Chym. xiv. 292.), and we frequently ſee the ſame effects from water cryſtallizing into ice. The effects of froſt on the ground from this cauſe, have been known from the earlieſt ages*, and ſimilar benefit may probably reſult from the cryſtallization of ſalts in more genial ſeaſons.

Light, in decompoſing water during the proceſs of vegetation, becomes the ſalutary agent whoſe influence we feel ſenſibly, during the day, in our renewed ſpirits and activity; the animating principle of life and health, the cauſe of colour in living animals, the ſource of heat from producing changes in bodies of almoſt every kind. On the human frame its effects are by no means peculiar, or unknown, though not yet traced with accuracy. The infant negro and native American are, we know, of a fairer hue than their parents, and become darker, as they advance in age. Dr. Bancroft attributes this change, with great propriety, to the combination of light with their reticular membrane: we have already ſeen, that light can penetrate, and produce its peculiar effects, through thicker coverings, than the cuticle and ſkin. The diſtinguiſhing principle of animal nature, in a chemical view, is, we have ſaid, the azote or baſis of phlogiſticated air, and with inflammable air the azote forms volatile alkali, which exiſts in every animal matter, combined with phoſphoric acid. Light ſeems to be an ingredient in volatile alkali, viſible only on its decompoſition, and phoſphorus appears to contain light in a conſiderable proportion, for it affords no heat when decompounded in vacuo, and is ſcarcely luminous, in its acid ſtate, when combined with vital air. As light therefore appears to be a component part of the two ſubſtances peculiar to animals, we may conclude that it has a more important effect than darkening the ſkin, or blackening the hair; and we ſhall immediately perceive why the fluids of the fœtus have no phoſphoric or ammoniacal ſalts, (An. de Chym. vii. 165.). All animal ſubſtances are highly phoſphoric, and, with gold and ſilver, form exceptions to the general rule, that the beſt conductors of electricity do not abſorb light or obſtinately retain it; for metals in general, water and mineral acids, never become phoſphoric, (Beccaria Comment. Bonon. 11. 96.). The yolk of an egg, when dry, is an excellent phoſphorus; the white can ſcarcely, by any management, be rendered phoſphoric. The Pholades (luminous fiſh) will not illuminate water, but render milk very brilliant; and the light of the ſea, when not owing to minute inſects, is ſeemingly produced by the ſpawn of fiſh, or putrid animal ſubſtances. It is obſerved only, when the water is glutinous and agitated, conſequently forms no exception to the fact juſt mentioned, the difficulty of rendering water phoſphoric. The ſuperior utility of iſinglaſs to every other varniſh, in preſerving the brilliancy of water-colours, uſually injured by the light, may be owing to the ſame property, derived from its animal nature. Light then ſeems to be an important agent in the animal œconomy; and, when we perceive the ſallow complexions, the languid circulation, and the cold extremities of thoſe confined, where little light enters, or none is reflected, we may perhaps conclude, that changes, uſually attributed to confinement and want of exerciſe, may in part be owing to a defect of this animating principle. Girtanner found white animals and white plants peculiarly weak and irritable.

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* "Gelidus canis cum montibus humor
"Liquitur, et Zephyro putris ſe gleba reſolvit."
Georg. I. 44.

If light however be the cauſe of colour in living bodies, it has a very different and oppoſite effect on dead animals, and on ſome vegetable ſubſtances. The doctrine of colours is ſtill very obſcure; and we can enlarge no farther on the ſubject than to connect it with the principal poſition which pervades this eſſay, that light and oxygene mutually ſeparate each other. In the operation of bleaching cloths, this mutual repulſion is rather between the adventitious ſubſtances, than the vegetable fibres to be whitened; for the acids employed, whether, as in the original proceſs, it be ſour milk, or, in ſubſequent more improved methods, oil of vitriol, and oxygenated ſpirit of ſalt, differ only in the facility with which oxygene is ſeparated from them by light. The vital air of acids is combined with the colouring matter of vegetable fibres, and the compound, which is tranſparent, leaves their white baſis unclouded. That ſuch is the foundation of the proceſs, is evident from many circumſtances connected with its ſucceſs; and we find that inflammable air, which cloth in this ſtate greedily attracts, deſtroys the brilliancy: even ſoap, in frequent waſhings, is decompounded, and the hydrogene of the alkali reſtores to the flax its original hue.

All bleachers know, that the two ſummer months are more ſerviceable than any other period; and the bleachers of Beauvois have particularly obſerved, that the moſt drying winds, with a cloudy ſky, are of little utility. Indigo, without any combination, is a fugitive colour; and experiments ſhow, that its change is owing to a ſeparation of oxygene. The colour of ink depends alſo on oxygene, for its baſis oxygenates the muriatic acid, and becomes tranſparent; but it is not deſtroyed by light, being combined with a metallic oxyd, which ſupplies the loſs. In various experiments of M. Sennebier, on the colours of vegetable ſubſtances, it has been found, that when the baſis contained a body capable of ſupplying oxygene, its hue was changed, but not deſtroyed: the brilliancy of carmine depends alſo on light; and ſo peculiarly delicate is its colour, that a ſingle cloud is fatal to the preparation. The colour of woods is equally connected with light; for the woods of the tropical regions are generally dark, and their ſhades are conſiderably more deep, after having been expoſed to an unclouded ſun. (Sennebier).

In animal ſubſtances, there is by no means ſo ſtriking a connection between the effects of light and the ſeparation of oxygene. Wax, which is an inflammable body, is certainly bleached in conſequence of the ſeparation of part of its vital air; and light is the principal, and, in reality, the only agent. (Anali di Chimica di Brugnatelli). Wool and ſilk partake of the uſual principles of animal matter, azote and hydrogene: neither is particularly affected by light, except when whitened by volatile vitriolic acid. Light will then deſtroy the brilliancy of theſe ſubſtances, by ſeparating the oxygene that had contributed to it, and which they had derived from the oxygenated acid. The apparent effects of light on dead animal ſubſtances, on colours originally derived from the ſun's rays, probably depend rather on general decay, than any particular effect of light as a chemical principle.

Light and oxygene ſeem, in theſe various inſtances, to repel each other; but oxygene owes its elaſtic form to the matter of heat, and appears to be heat, (the caloric of the French chemiſts), in its leaſt compounded ſtate. If, therefore, light ſeparates oxygene in the form of vital air, it muſt ſeparate caloric alſo; and heat and light, which have been generally conſidered as the ſame principle, or different modifications of one ſimple element, will appear to be two diſtinct and mutually repulſive fluids. Various facts ſupport this opinion; and it requires no profound ſagacity to diſcover, that the ſimultaneous appearance of caloric and light, in conſequence of the decompoſition of bodies which contain them, is as compatible with two mutually repulſive bodies, as with the ſame element in two different ſtates.

Heat is diſtinguiſhed from light by various properties. Light paſſes through glaſs, while heat is excluded: it penetrates bodies of a peculiar ſtructure, and is reflected by thoſe of a different nature; but heat unites with every ſubſtance, and ſoon attains a perfect equilibrium. The progreſs of reflected or refracted light is rapid and uniform; that of heat variable in different media, without any inflection, frequently without being reflected *. Heat, in every inſtance, promotes the liquefaction of bodies, light contributes to their aſſuming ſolid forms; and ſo diſtinct are the effects of light and heat, that light paſſes with unimpaired power through plates of ice, (Senebier, II. 346.), and the growth of vegetables is aſſiſted as by the ſun, without any interpoſition. Water checks the progreſs and ſeparation of heat, but neither impedes light, nor prevents the ſplendor of phoſphoric bodies. Heat combines with air of every kind, and forms an eſſential ingredient in each; but light does not unite with atmoſpheric air, and probably with no other gas.

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* M. M. Lambert, (Pyrometrie, § 378, &c.), and Pictet, (Eſſai ſur le Feu, § 49, &c.), found, that heat, independent of light, might be reflected and concentred in a focus; yet they acknowledge that the heat accumulated is greater if joined with light, even when the temperature of the body affording it is leſs. On comparing, however, the experiments of M. Pictet, § 49. and § 54. there is reaſon to ſuſpect, that light, though not viſible, had a ſhare in the event.

Light, which combines with neither air nor water, when accumulated in the focus of a ſpeculum, produces no heat in either. Bodies which ſuffer the light to paſs through their ſubſtance, are uninjured; and the focus of Trudaine's large ſpeculum, which would ſcorify any opaque body in an inſtant, had no effect on a thin tranſparent piece of glaſs, (Macquer). A glaſs mirror, which reflects light with little loſs, and heat leſs perfectly, ſoon grows warm, while a concave ſpeculum, which reflects both equally, continues for a long time cool. Heat, when applied to manganeſe and other metallic calces, ſeparates the phlogiſticated air only; but, when combined with light, in a red heat, ſeparates their vital air. (Berthollet and Fourcroy, A. de Chym. 1. 50. 81.). M. Wedgwood, junior, (Phil. Tranſ. 1792), found, that a blackened cylinder began to grow red in the fire in two-thirds of the time a poliſhed cylinder required, ſo that the reflected light leſſened the heat produced; and, inverſely, the blackened cylinder ceaſed to ſhine proportionally ſooner.

Gold, ſilver, copper, and iron, when blackened, became luminous in the ſame order, in the *inverſe* ratio of their ſpecific heats.

Dr Higgins, a chemiſt of conſiderable reputation, conſiders light and heat as the ſame principle; heat as *luminous*, when thrown off with a rapid projectile motion, and *hot*, when this motion is checked or ſtopped, (Philoſophical Converſations, p. 302.). Facts, however, ſcarcely ſupport his opinion; for light is retarded and arreſted in its motion, when combined with phoſphoric bodies, but does not produce heat; and, when heat is the conſequence, it appears to have been ſeparated from the body, inſtead of having been brought by the light; for after inflammation is begun, the exciting principle is no longer required. He obſerves alſo, that, in burning bodies, light appears, cæteris paribus, proportional to the velocity with which the caloric is emitted; and when emitted ſlowly, or where its projection is impeded, no light is obſervable. Yet in the phoſphoriſm of tallow * and phoſphorus, the combuſtion is ſlow, and the light is unattended by heat. He admits the laſt to be a true oxygenation, and allows, that the light, in the moſt dreadfully violent exploſion of argentum fulminans, where the projectile force muſt be rapid, is only a momentary gleam, " without any adequate effect of heat." The light, as he alleges, *may* be brighteſt in ſubſtances from whoſe combuſtion no gas is produced, for a reaſon very different from that he has aſſigned. If light and heat repel each other, the light muſt be greateſt when the heat is moſt active; but, in the formation of gas, heat is immediately abſorbed, and its repulſive power will be leſs conſpicuous. The experiment, adduced by Dr Higgins in ſupport of his poſition, where pyrophyrus, which kindled in the neck of a mattraſs filled with nitrous vapour, was not luminous in the acid below, is ſtill leſs concluſive, ſince conductors of electricity, among the moſt powerful of which are mineral acids, do not admit of the ſeparation of light. To which may be added, that the pieces which fell into the acid were "of a coarſer grain, and a cloſer texture" than thoſe which kindled in the vapour; and it is well known, that the goodneſs of the pyrophorus which he employed, is in proportion to its lightneſs and ſpongineſs.

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* The beſt method of obſerving the phoſphoriſm of tallow, is by melting a candle over a warm coal, juſt as the red heat has diſappeared.

While light and heat, therefore, uſually appear to be antagonizing principles, they ſeem to be combined in inflammable bodies, by a peculiar power of attraction, and their mutual repulſion becomes only conſpicuous from decompounding the ſubſtance. In ſome inſtances, additional light ſeems to operate by ſetting heat at liberty; in others, heat ſeparates light. Thus, for inſtance, light only will not kindle inflammable air, and many mines are enlightened by ſparks from flints and ſteel, which we ſhall find to be in themſelves luminous only: the greateſt heat, without light, will not enflame a mixture of vital and inflammable air, (Gadolin, An. de Chym.

xvii. 107.); and heat only will not inflame gunpowder, ſpirit of wine, camphor, oils, reſins, &c. In various inſtances, where light would have occaſioned decompoſition, the power of attraction muſt be weakened by heat, before inflammation can begin. The violence of the ſeparation ſeems to depend in part on the proportion of theſe principles, and in part on the force of attraction between them and the other ingredients.

Many bodies are phoſphoric in a double ſenſe: they emit light, which they have imbibed, and that which formed a component part of the body may be alſo ſeparated by a degree of heat below what is neceſſary for their inflammation. Light from decompoſition is blue, from ignition red; the proceſs in the former inſtance is ſlow, in the latter rapid, (Fordyce, Phil. Tranſ. lxvi. 506.). Mr. Wedgwood, jun. in the volume formerly quoted, hath examined the light produced by bodies not ignited, and from bodies raiſed to a red heat by attrition. The luminous appearance of bodies not ignited might be repeated;

peated; but the repetition was limited. Subſtances thus rendered luminous by heat, are ſlowly decompoſed; and this diſtinction reconciles the opinions of Mr. Wilſon and Mr. Morgan. The former calls the illumination of phoſphorus a ſlow combuſtion, which is true only of thoſe phoſphoric bodies which are rendered ſo by heat: theſe were firſt deſcribed by Margraaf, (Berlin Tranſ. An. 1749, p. 70.). Phoſphoric phænomena, produced by attrition, are not of the ſame kind, for, in different experiments, the ſame bodies were phoſphoric in different degrees. All the appearances of light from attrition appear to be truly phoſphoric, and the heat, occaſionally produced, to be a ſecondary effect; for a flaſh of light uſually pervades the whole ſubſtance, (Macquer), and the light is equally obſervable under water. M. Pictet found a brilliant pyramid of ſparks, ſtruck from ſteel by flints, had no effect on a nice thermometer: when ſtruck in an exhauſted receiver, light alone is viſible, and the ſteel is not fuſed. When two hard ſubſtances were rubbed together, no heat appeared; and it was only ſenſible, on attrition of hard and ſoft wood, when the latter was in part deſtroyed, and its caloric conſequently liberated. The neceſſary preſence of a body, which can afford the heat, may perhaps contribute to illuſtrate a fact, obſerved by Count Rumford, (Phil. Tranſ. An. 1781.). He remarked, that a cannon was much more heated when fired with powder only, than when a ball was added. In reality, the reſiſtance of the ball admits of a very ſmall proportion of air, till it eſcapes from the gun, while the looſer wadding is diſſipated with the deflagration of the firſt portion of the powder fired. The air, from which the heat proceeds, is admitted in the latter inſtance, before the whole charge explodes, and the heat is conſequently more ſenſible: in the former, the little heat ſeparated is immediately combined with the gaſſes produced.

In a common fire, heat and light eſcape at the ſame time, with little violence, and ſeldom with any detonation. Bodies placed within their influence imbibe both, and loſe each at different periods, without any chemical change, unleſs they contain heat or light in their compoſition, or are capable of attracting them ſo as to form a new compound. In the inſtances of metallic oxyds and lime, heat is attracted; in that of the common pyrophorus, light. Both are ſeparated, from inflammable ſubſtances in general, ſlowly and without violence; but with rapidity and an exploſive impulſe, when each ingredient is at once liberated, in an active form, with its mutually repulſive power. Gunpowder, when heated ſlowly to a degree ſufficient only to inflame the ſulphur, without melting the nitre, is as innocent as the flame of a common match; and phoſphorus, when warmed ſo carefully as not to ſeparate its heat, allows the light to paſs off in innocent coruſcations. The violence of each, when their heat and light are at once liberated, is well known.

To eſtabliſh more fully the poſition juſt ſtated, that exploſions are chiefly owing to the ſimultaneous ſeparation and mutual repulſion of heat and light, it is neceſſary to trace light, as a chemical principle, in various compounds, where its preſence has not been often ſuſpected. The facts have been in part anticipated, for the illuſtrations formerly adduced have been ſelected with a view to this concluſion.

The pneumatic chemiſts have analyzed nitre with particular accuracy; and the gaſſes of which it is compoſed are known to float in every region, among the atmoſpheric fluids. Yet nitre is the production chiefly of unclouded ſkies, where the ſolar light can combine with it, unimpaired. We have ſeen that light unites with every fertile ſoil, and particularly with one of the ſubſtances preferred for the extraction of this ſalt, viz. the rubbiſh of old houſes. The manufacturer, not contented with expoſing his materials to the air, turns them often, that they may imbibe, perhaps, light more copiouſly, for, in this reſpect only, the plains of Languedoc and Hindoſtan differ from thoſe of Britain. We find the light on decompoſition, in the brilliant ſparks which nitre produces when combined with any inflammable body, but the light ſeems to be retained with obſtinacy, and without an exciting cauſe to paſs off ſlowly, ſince the ſalt may be melted in a red heat, without deflagration. The addition of inflammable matter, however, gives activity to the luminous principle, and both eſcape with violence. If the heat be gradually applied, without any addition, it is combined with the acid, the reſult of their union, and does not exert a repulſive power; but the acid is ſeparated in the red fuming ſtate, which it acquires by being expoſed to light, and which the white acid will aſſume, even from the flame of a candle, (Scheele, ap. Crell's Journal, Eng. Tranſ. iii. 198.).

We have ſeen light combining with vegetable ſubſtances, and we may again expect it from their decompoſition. Farinaceous ſeeds, particularly the ſeeds of plants called antiſcorbutic, make both phoſphorus and pyrophorus (Chaptal); and the finer particles of meal, when forcing their way through an aperture from an upper chamber, exploded with great violence, in conſequence of a light fixed againſt the wall, at ſome diſtance,

tance, (Count Morozzo, Turin Tranſ. 1786-7.). When vegetable ſubſtances are charred, an operation in which the heat and light are partly ſet at liberty, and forced again to combine, in a ſlighter union, with the coal, we ſee them ſeparate, on the addition of an inferior degree of heat, with ſparkling detonations; and charred farina, with allum, forms an excellent pyrophorus. In this inſtance, perhaps, the allum furniſhes the heat from the decompoſition of its acid, and the clay contributes to keep the maſs from agglutinating, ſince the excellence of ſuch pyrophorus depends on its light ſpongy texture. Of this kind was the pyrophorus of Dr. Higgins.

Animal ſubſtances equally imbibe light and heat; and the appearances which attend the decompoſition of their diſtinguiſhing principles, phoſphorus and volatile alkali, contribute to illuſtrate a prior union. In ſome inſtances, light is ſeparated by the animal functions, as in fire-flies and glow-worms. In the glow-worm, and probably alſo in the fly, it is ſeparated by a kind of excretion, and, except ſolar light, is probably the ſimpleſt form of that element, (Beckerheim, An. de Ch. iv. 19.), for the glow-worm does not injure the airs in which it has lived. Yet this light, when joined with inflammable air, in which heat is in a ſtill larger proportion than in vital air, will form an exploſive compound, on the additon of external heat, though the inflammable air will not explode alone. Oyſter and egg-ſhells, (probably from their animal nature), as well as calcareous earths in every other form, contain light, which they occaſionally emit, and in ſome inſtances, as in Canton's and Baldwin's Phoſphori, are capable of exploding, (Phil. Tranſ. lviii. 337. Mem de l'Acad. An. 1693.). When calcareous earth is calcined, it is combined with heat, and the light is ſeparated; for in no inſtance can I diſcover any phoſphoric or exploſive qualities in lime, except where light is alſo a part of the compoſition. In Homberg's ammoniacal phoſphorus, (Mem. de l'Academie, An. 1693.), the light is afforded by the volatile alkali.

This ſalt is diſcovered to contain light, by becoming intenſely luminous in a heated crucible, and by the copious red flaſhes obſervable, when it is added to the marine acid vapour. Sulphur alſo contains light, though in a leſs proportion, and a weak degree: it is ſeemingly derived from the ſun, for the pyrites grow hot in the open air, previous to the ſublimation of ſulphur, or from the red heat, to which they are ſubjected in the proceſs.

Theſe are the principal ingredients in fulminating powders*; and when the ſource of the light which they diſplay is inveſtigated, many proofs of the mutual repulſion of light and heat have occurred. But it is neceſſary to examine the compoſition of the different ſubſtances, and to trace the cauſe of their exploſions more particularly.

The ingredients of gunpowder are well known; and its excellence depends on their minute and intimate union. The light, from a ſpark of ſteel, will inflame the ſulphur, which will explode with the nitre, ſetting at liberty light and heat with

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a violent exploſion, in each ſucceſſive grain of the maſs. This explanation is by no means hypothetical, for we know that, in the largeſt charge, grains of gunpowder explode in ſucceſſion, and that light, or a red heat, is neceſſary to the effect: when charcoal falls into melted nitre, or nitre into flaming ſulphur, the conſequence is ſimilar. The compoſition only increaſes the exploſion, and the intimate union of the particles admits of its beginning in the moſt minute maſs. Dr. Higgins reluctantly confeſſes, (l. c. p. 315.), that charcoal does not deflagrate in melted nitre, unleſs one of the ingredients be red hot, however near the temperature may be to a red heat; and, in explaining ignition from a ſpark, (p. 319.), allows that its caloric is much leſs than can be imparted by heat.

Pulvis fulminans reſembles gunpowder in its nature and properties; the ſalt of tartar, a vegetable ſubſtance, which ſeems to contain light, ſupplying the place of charcoal. It differs in the ingredients not being intimately united, and conſequently the compound muſt be melted, in ſome quantity, before the exploſion will take place; for, if heated ſuddenly, the ingredients will deflagrate ſeparately. In this caſe, as well as in the exploſion of fulminating gold, Dr. Higgins allows that a particle of luminous charcoal will ſupply the place of more intenſe heat.

The union of oxygenated acids with alkalis, or calcareous earths, as containing both heat and light, ought, if the preceding obſervations be juſt, to increaſe the liſt of exploſive compounds. The oxygenated muriate of potaſh (fixed alkali, united with oxygenated muriatic acid) will explode; oxygenated nitrate of potaſh with greater certainty, (Carradon, An. de Chym.), for the light is more copious in the latter than in the former. The French chemiſts in the compoſition of gunpowder, have endeavoured to ſubſtitute, on this account, the oxygenated ſalts for nitre, but as theſe ſalts explode in conſequence of attrition, many fatal accidents, particularly that at Eſſone, have prevented their adopting more generally this plan. It is probable, that theſe ſubſtances fulminate leſs certainly from heat alone, becauſe they do not contain a large proportion of light, for M. de Sage diſcovered a violently fulminating ſalt, in a ſchorl from Veſuvius, which on examination appeared to be a calcareous oxygenated ſal ammoniac, in which the volatile alkali probably ſupplied additional light.

Oxygenated muriate of potaſh fulminates violently, when put into the ſulphuric acid; the exploſion is repeated with a brilliant flaſh on every new agitation, and again on the application of the flame of a candle; the ſalt thrown out is luminous, and crackles for many ſeconds. The exploſion of nitre, when made with oxygenated acid, is ſtill more violent; and, on the ſame principles, the *fuming* ſpirit of nitre, a quality which it derives from the ſun's light, explodes with eſſential oils. A candle, in oxygenated marine acid air, burns with an enlarged flame; and phoſphorus, as well as every other inflammable ſubſtance, explodes in the ſame air; facts which have occaſioned ſome controverſy, but ſeem to be now well eſtabliſhed, (Crell's

Annals, Engliſh Tranſ. I. 144. II. 157.). A mixture of phoſphoric acid air and oxygene, when joined with nitrous gas, exploded with great violence, (Pelletier, An. de Chym.).

Fulminating gold is known to be an oxyd of that metal, combined with volatile alkali, (Scheele on air and fire, 137.—140.), conſequently containing heat and light in a conſiderable proportion. But the light which the volatile alkali contains, is greedily attracted by the gold; and the oxygene of the calx contributes to the gaſeous form of its ingredients. When, therefore, the attraction of the volatile alkali for its light, is in any degree weakened, the latter will be attracted by the gold. The heat, thus ſeparated, contributes to form the gaſſes, which explode with violence. This is certainly the reaſon of its fulminating, for the alkali is loſt, and gold reſtored with its metallic ſplendor. The event is inexplicable, except on the foundation explained, aſſiſted with Scheele's remark, that a calx of gold may be reduced by light alone. The explanation, uſually given,

ven, reſts on the formation of gaſſes; that which is now offered proceeds one ſtep farther, and attempts to explain the cauſe of their recovering an elaſtic and active form. Sulphuric æther, which contains light in a large proportion, produces the ſame effect as the volatile alkali, (Gottling, Annales de Chymie, xii. 106.).

The heat, in the exploſion of aurum fulminans, is inconſiderable, for it is almoſt immediately abſorbed by the baſis of the gaſſes: in the exploſion of argentum fulminans, it is ſcarcely obſervable. The latter, an oxyd of ſilver, precipitated by lime-water, poſſeſſes an unuſual proportion of caloric; but is afterwards digeſted with the pureſt volatile alkali for three days in a ſtrong ſolar light. The fulminating ſubſtance is therefore charged with heat and light in conſiderable proportions; and the ſlighteſt attrition will occaſion a ſeparation: the exploſion is dreadfully violent. In argentum fulminans light ſeems to predominate, and to be the chief agent for attrition is neceſſary to produce the effect, to which the heat of boiling water is unequal. Attrition, we have ſeen, ſeparates light, that had been an ingredient in compounds; and it will ſeparate this principle from almoſt every ſubſtance which contains it in a large proportion, from aurum fulminans, oxygenated muriate of potaſh, and the calcareous phoſphate of Eſtremadura, (An. de Chym. vii. 81.).

A doubt has lately ariſen, from ſome ingenious experiments of Mrs Fulhame, whether light alone will reduce ſilver and gold: ſhe thinks the hydrogene of decompoſed water alſo neceſſary, and ſeems to have ſupported its utility by ſtrong facts. The additional agent will make no eſſential change in the above concluſions, and I have mentioned the obſervation only to introduce a fact from Morveau, (An. de Chym. ix. 4. and 6.), which ſeems deciſive in oppoſition to her doctrine. Nitrate of ſilver was reduced in *white* glaſs-tubes, hermetically ſealed, when expoſed to a red heat, but remained unaltered in tubes of *green* glaſs.

A leſs violent exploſion, in which light ſeems to have the chief ſhare, occurred to Dr. Pearſon. A combination of quicklime and phoſphorus contains both heat and light; and the union is ſo ſlight, that this liver of phoſphorus, as he ſtyles it, will explode even with the warmth of the tongue.

Prince Rupert's Drops, Lacrymæ Batavicæ, vel Boruſſicæ, for they are known by all theſe appellations, are formed by dropping ſome green or black glaſs, while melted, into cold water. The form which the drop of glaſs aſſumes is that of a retort; and breaking the ſlighteſt portion of the neck burſts the whole in ſmall pieces: when broken in vacuo, it explodes in a powder. The phænomenon reſembles the cracking of glaſs not annealed; and many of the drops will not even ſuſtain the contact of cold air. A gleam of light only, without heat, attends the exploſion. In the formation of theſe drops, heat is certainly carried off, but the light is confined: it cannot permeate the black glaſs; it cannot be conveyed away by the water. This element is however reſtored to activity

vity by deſtroying the continuity of the cruſt, formed by the external portion of the glaſs, which is hardened by the cold water, and its eſcape ſeems to ſcatter the whole in the moſt minute particles. The ſalt of glaſs, the ſcum which riſes on the ſurface when the marine barilla is employed, if taken from the melted metal, explodes in the air, and is an inſtance of fulmination ſimilar to that of Prince Rupert's Drops. The alkali is made from a marine fucus, which on diſtillation affords a volatile alkali, and other animal products, conſequently contains light in a large proportion. By the continuance of heat it might be gradually decompounded; but when its light is confined by the cooling of the ſurface, the whole maſs burſts with violence *.

The paſſage of the electric fluid, from one conductor to another, ſeems to be an exploſion of light only. Dr. Latham has lately ſuggeſted, (Higgins' Phil. Converſ.), that it is owing to the inflammation of the air through which the electricity paſſes; but

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* Repertory of Arts and Sciences, v. 4. p. 420.

but a fact recorded by Mr. Morgan, (Phil. Tranſ. lxxv. 203.), ſeems deciſively to controvert this opinion. He found the electrical fluid, in vacuo, darting between two contiguous wires with the ſame brilliancy as in open air. This fluid never appears to us but in the form of light, and its affinities or its effects are in no inſtance thoſe of heat, except when the caloric is furniſhed by bodies decompoſed or deſtroyed by the charge. Thus it fuſes iron without inflaming the ſubſtance around, and deſtroys animal life, without expanding the fluids, or rupturing the veſſels. In rarefied air, it eſcapes in harmleſs coruſcations, like the phoſphoric light, and is ſeemingly loſt in the brilliancy; in other air, it appears alſo to eſcape in light, leaving the gaſs it paſſed through inflammable. In chemical changes, it acts as light only, kindling ſubſtances which heat alone cannot raiſe into a flame, and failing to kindle thoſe which light will not affect. When reſiſted it becomes luminous, and paſſes through bodies which, in its former probably more denſe or more compounded

ſtate,

ſtate, reſiſted its progreſs; and is repelled by bodies which it cannot penetrate or decompoſe. Like light, the electric fluid renders phoſphoric bodies luminous, and ſubſtances become ſo in the inverſe ratio of their conducting powers, (Morgan, l. c.): like light from the decompoſition of bodies, it is blue before it becomes red and white; and is affected by the priſm as ſolar light, (Morgan). The electricity of the tourmaline is excited by warmth, and not repelled by water; a circumſtance in which it agrees with the luminous appearance afforded by many bodies which contain light. Electrical atmoſpheres ſeem, like light, to ſeparate heat, for they convey or excite heat more readily and intenſely than a vacuum, (Pictet, § 108.): probably the electric fluid itſelf may develope heat from the air, or its light may produce the ſame effect. In ſhort, various facts ſeem to ſhow, that light is a copious ingredient in the compoſition of electricity, perhaps the cauſe of its activity, influencing very ſtrongly its affinities.

If the ignis fatuus be the electrical light, or the air of marſhes illuminated by electricity, we can eaſily explain why it appears to fly from the perſon who attempts to purſue it, and, in one ſingular inſtance recorded by Dr. Prieſtley, ſeemed to follow a perſon who came from a cloſe room where electrical experiments had been made. In the evening of a warm day, when this meteor appears, the electricity of the air is poſitive, and of the ſame kind as the human body: they therefore repel each other; but the electricity of the air of a crouded room is negative, (Read Phil. Tranſ. 1794), oppoſite to that of the body, and conſequently attracted by it.

The facts, thus accumulated, appear clearly to prove the mutual repulſions, the antagoniſing powers of heat and light, and to elucidate, often very ſtrikingly, many chemical facts, many natural phænomena. Here, then, the proofs muſt for a time reſt; but I ſhall beg leave to enforce them by ſome meteorological phænomena, and the aſtronomical obſervations of Mr Herſchell.

The heat we ſeem to feel from the ſun, is moſt probably ſeparated from the earth, or from our bodies, in conſequence of the influence of its light; and, when ſeparated from ourſelves and the objects around, the warmth is equable and pleaſing. But when the ſun ſhines after a ſhower, and the heat elicited from the earth becomes a part of the air newly formed, we then feel its influence only on ourſelves, and we complain of an unpleaſing heat, as from the partial warmth of a fire. Though the earth is cooled by evaporation, we do not feel this partial influence in the cloudy weather of ſummer. The veſicular vapour is warmed, and communicates the heat more gradually. On high mountains the air is extremely cold, and the heat ſcorching; for no reflected heat is felt, and no veſicular vapour communicates it equably. The obſervations of M. Pictet materially illuſtrate this ſubject. He found a thermometer, at five feet from the earth's ſurface, coincide in its changes with one at ſeventy-five feet, only in a cloudy day, when the warmth was communicated by the veſicular vapour: they coincided too, when the thermometer near the earth was ſhaded from the immediate influence of the ſun. The coldeſt part of the night was always immediately before ſun-riſe. Theſe facts are only explicable on the ſyſtem originally ſuggeſted by M. de Luc, that the ſun is a luminous body, and the remote, not the immediate cauſe of heat.

Theſe facts will contribute to ſupport the opinion which Mr Herſchell has derived from his obſervations, and we may ſafely conclude, that the ſun is a luminous body, or rather opaque in its ſubſtance, and luminous in conſequence of an atmoſphere of light. From the ſame ſource we may probably conclude alſo, that light is tranſparent, and inelaſtic; for the body of the ſun is viſible when the maſs of ſurrounding light is diminiſhed, and the ſpots appear to be excavations with ſhelving ſides. Thus, even the light within our power is tranſparent, and ſeemingly inelaſtic; for the flame of a candle, impelled by a blowpipe, is at its extremity tranſparent; and the light of the ſun, collected in a focus, and thrown into the middle of an exhauſted receiver, is inviſible; nor can we find, in any experiment, light capable of compreſſion, and of conſequent expanſion.

I may be allowed, perhaps, to ſuggeſt an opinion, not eſſentially different from thoſe of M. M. De Luc, Scheele, and Herſchell, but more comprehenſive and probably more ſtrictly chemical. The ſun we know to be a body of conſiderable magnitude, and of a denſity inconſiſtent with its being a maſs of actual fire or light. May we not ſuppoſe it then to be a ſolid, in which light is a copious ingredient, and decompoſed on the ſurface, where it is unreſiſted, and where only the accumulation of a luminous atmoſphere ſets limits to a farther decompoſition. This atmoſphere,* from its repulſive energy, and from the centrifugal force, will be conſtantly paſſing away, and other parts of the vaſt maſs will, in turn, aſſume its luminous activity: an idea which will relieve the mind of the gloomy ſpeculator, who fears, that the ſun may decay, and the regularity of the planetary motions be diſturbed. Dr. Horſley has already ſhown, that, as probably ſome reflected light may return, and, as it is not neceſſary, on the grounds ſtated in the firſt part of this Eſſay, that the diſcharge of light ſhould be unremitted, the ſun will not loſe $\frac{1}{13232}$ part of his diameter in more than one hundred and thirty-five millions of years. Though the admiſſions juſt mentioned be not allowed, yet the apprehenſion will perhaps continue equally groundleſs. The particles which iſſue from an inch of phoſphorus, converted into light, are too numerous for calculation; and if we ſuppoſe the ſun

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* Though I ſpeak of an atmoſphere only, yet it is the atmoſphere of a maſs exceeding 800,000 miles in diameter, in no part probably leſs than 334 miles in depth, while in the faculæ, which may be called the ſpring-tides of the ſolar atmoſphere, it riſes more than 2000 miles (the mean of 1843 and 2765 miles, the extremes of Mr. Herſchell's obſervations).

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vations). On the contrary, two contiguous ſpots viſible in 1779 to the naked eye, but not leſſening the brilliancy of the ſolar light, were together equal in length to more than 50,000 miles, more than twice the circumference of the earth. (Herſchell).

luminous in no greater degree, myriads of ages will paſs away, before its diameter can be eſſentially leſſened: in other words, it will laſt with unimpaired luſtre, till that moment, when, by the Almighty FIAT, every thing will have an end.

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THE END.

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